FINAL REPORT

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Analysis of Auto Industry and Consumer Response to Regulations and Technological Change, and Customization of Consumer Response Models in Support of AB 1493 Rulemaking –

Case Study of Light-Duty Diesel Vehicles in Europe

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ABSTRACT

Diesel vehicle sales in the European Union have increased from 23% of all light duty vehicles sold in 1994 to 41% in 2002. This rapid increase in market penetration is due to four related factors: a voluntary agreement by European automobile manufacturers in 1998 to reduce CO_2 emissions from new light duty vehicles by 25% from 1995 levels by 2008; significant advances in diesel technology; preferential fuel and vehicle pricing in most European countries; and preferential European Union regulation of diesel emissions. However, the growth in sales is not uniform throughout Europe, largely due to differences in fuel and vehicle pricing.

EXECUTIVE SUMMARY

Diesel vehicles are steadily increasing their share of the European light duty automotive market. Sales of diesels in the European Union have nearly doubled between 1994 and 2002, from 23 percent to 41 percent. Four factors explain this growth: improved diesel technology, fuel and vehicle taxation policy that favors diesels, air pollutant emission policies that favor diesel, and a voluntary agreement by automakers to reduce carbon dioxide (CO_2) emissions per vehicle kilometer by 25 percent between 1995 and 2008.

The voluntary agreement is key. It provides the overarching policy framework for industry, national governments, and local governments to support diesel engines (and other technologies that emit less CO_2). The automotive industry is focusing on diesel engines as the best way to achieve the CO_2 reduction goal, and a variety of measures have been put in place to support this strategy. Diesel engines are indeed a credible strategy to reduce CO_2 emissions. The mix of new light-duty diesel vehicles in 2002 for the entire European Union consumed about 20 percent less fuel and emitted roughly one-tenth fewer CO_2 emissions per kilometer than average new gasoline vehicles.

Improvements in diesel technology have been important to the upsurge in diesel sales. European automakers have invested heavily in advancing diesel technologies. These improvements have changed the common perception of diesels as heavy, noisy, and polluting, enhancing their appeal to a broader range of consumers—not only those looking for sizeable fuel savings. Those improvements continue. Diesel vehicles are now roughly equivalent in performance to gasoline vehicles, though consumers pay a premium for the additional fuel savings.

The surge in diesel vehicles sales has been facilitated by European emission standards that, unlike the United States, allow diesel engines to emit more particulate matter and nitrogen oxides than gasoline engines. Emission improvements have been dramatic, but still lag gasoline technology, especially for nitrogen oxides.

Diesel vehicle market shares are not uniform across Europe, however. Differences are largely explained by differing taxation policy – mostly related to fuels and vehicles. In some countries, diesel fuel is priced as much as 40% less than gasoline fuel, which can lead to substantial savings in fuel expenditures when combined with the improved fuel economy of diesel vehicles. In other countries, registration and annual ownership taxes are structured specifically to encourage purchasing low CO_2-emission vehicles. Together, favorable vehicle and fuel taxation policies have clearly played a central role in expanding light duty diesel vehicle sales in Europe.

1. INTRODUCTION

The European Union (EU) signed the Kyoto Protocol in 1997 pledging to reduce its emissions of greenhouse gases 8 percent below 1990 levels by 2008-2012. [1] Carbon dioxide (CO_2) is the most prevalent of greenhouse gases, and combustion of fossil fuels is the principal source of anthropogenic CO_2 emissions. The transportation sector accounts for 28 percent of total CO_2 emissions in Europe, with roughly 12 percent of the total produced by passenger vehicles. [2] To comply with the pending Kyoto Treaty and to pursue an overall goal of reducing greenhouse gases, the European Council and Parliament—the EU's legislative bodies—established a goal of reducing CO_2 emissions from new passenger vehicles to below 120g CO_2/km by 2005, or 2010 at the latest. It was stated that most of these reductions would be achieved through technological measures taken by industry with the remainder through consumer demand measures such as education and fiscal incentives that would encourage the purchase of more efficient vehicles.

The regulatory body of the EU, the European Commission, began negotiating with automakers in the mid 1990s to reduce CO_2 emissions from passenger vehicles. In 1998, the European Automobile Manufacturers Association (ACEA) voluntarily agreed with the European Commission to reduce average CO_2 emissions from new vehicles below 140g CO_2/km by 2008 (equivalent to about 41 miles per gallon of gasoline), representing a 25% reduction from 1995 levels. The agreement applies only to M_1 category vehicles, defined as vehicles used for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat. Members of ACEA include BMW, Daimler Chrysler, Fiat, Ford of Europe, General Motors Europe, Porsche, PSA Peugeot Citroen, Renault, Scania, Volkswagen, and Volvo. In addition, ACEA committed to an interim target of 165-170g CO_2/km for 2003, when it would also evaluate the potential of achieving an industry average of 120g CO_2/km by 2012. The voluntary agreement indicated that by the year 2000 some individual vehicle models would be introduced that emit less than 120g CO_2/km. Should the industry achieve its target reductions, the voluntary commitment is estimated to account for over 15% of the EU's total reductions required by the Kyoto Protocol. [1]

ACEA's voluntary commitment is based on several important conditions. The first assumption is that clean fuels (less than 50 ppm sulfur content) will be widely available by 2005 to enable the application of catalysts and particulate filters whose effectiveness is highly sensitive to sulfur levels. Second, non-ACEA automotive companies would be required to make equivalent commitments to reduce CO_2. In 2000, the Japanese and Korean Automobile Manufacturers Associations, comprised of all companies headquartered in those countries, agreed to similar objectives, thereby resulting in all major international automakers agreeing to the same voluntary standards. Thirdly, the commitment was adopted with the condition that failure to make sufficient progress towards achieving this goal would result in legislative action in 2008. Lastly, the Commission would not hinder the diffusion of CO_2 efficient technologies by such measures as tightened vehicle emission standards.

A voluntary agreement is a unique approach to regulating emissions, and contrasts with the policy approaches used in the United States (and Japan). In the US, the federal government imposes mandatory performance standards for fuel economy and air pollutant emissions, a more adversarial and legalistic approach. The then-president of ACEA, Bernd Pischetrider, Chairman and CEO of BMW, stated at the time of the agreement that “the voluntary approach will provide much greater flexibility. In particular, one of the main objectives of ACEA’s collective commitment is to preserve the rich diversity of product offering within Europe’s car manufacturers for the benefit of our customers and the entire EU economy.” [3 1998] By establishing an industry-wide standard, the agreement acknowledges that reductions are less costly for some manufacturers than others and that emission levels vary widely among different vehicle types. Thus, individual manufacturers are not bound to meeting specific targets. Additionally, because improved fuel economy implies a tradeoff with other attributes such as vehicle size or horsepower, an individual manufacturer may be reluctant to introduce a new technology for fear of losing market share to competitors who have not made a similar tradeoff. However, a voluntary agreement applicable to all manufacturers may minimize such risks if the entire industry is working collectively towards the target reductions. [4]

By 2002, CO_2 emissions of new vehicles sold in Europe had fallen to 166g CO_2/km, meeting the interim target ahead of schedule. [5] However, manufacturers are resisting recent discussions with the European Commission to establish a new reduction target of 120g CO_2/km for 2012. [6] Automakers contend that the cost of achieving such large reductions in CO_2 would be far more than consumers are willing to pay. In a study commissioned by ACEA, Arthur D. Little management consulting company found that the cost of meeting the new target would amount to $61 billion each year for the industry or about $4,900 per vehicle, mostly from changes in the powertrain. [7] To date, ACEA will only publicly commit to the original target of 140g CO_2/km by 2008. [6] Meanwhile, the European Commission seems intent on reducing emissions to the 120g CO_2/km level between 2005 and 2010.

2. MANUFACTURERS’ PERSPECTIVE ON LIGHT-DUTY DIESEL VEHICLES

Diesel vehicles as a CO_2 reduction strategy

Light-duty diesel vehicles are considered one of the major technologies for achieving short-term reductions. Although diesel fuel is roughly 15% more carbon-intensive than gasoline per volume, the higher fuel efficiency of diesel vehicles results in fewer carbon emissions per mile. [8] The difference in efficiency stems from the fact that diesel fuel contains about 11% more energy per volume than gasoline and that diesel engines are able to operate at higher compression, allowing for a more efficient combustion process. [9] In almost all countries, the difference between diesel and gasoline fuel consumption has been increasing since 1995, with the average diesel vehicle widening its fuel economy advantage. By 2002, diesels in the EU averaged 20% lower fuel consumption per kilometer than gasoline vehicles. Fuel consumption of gasoline vehicles has not remained stagnant, though, with gasoline consumption also falling each year in every country. Figure 2.1 compares the average fuel consumption of new diesel and gasoline vehicles sold in the EU and its member countries. However, these averages reflect sales volumes of models. Comparing equivalent versions of gasoline and diesel vehicles reveals diesels consuming about one-quarter less fuel per

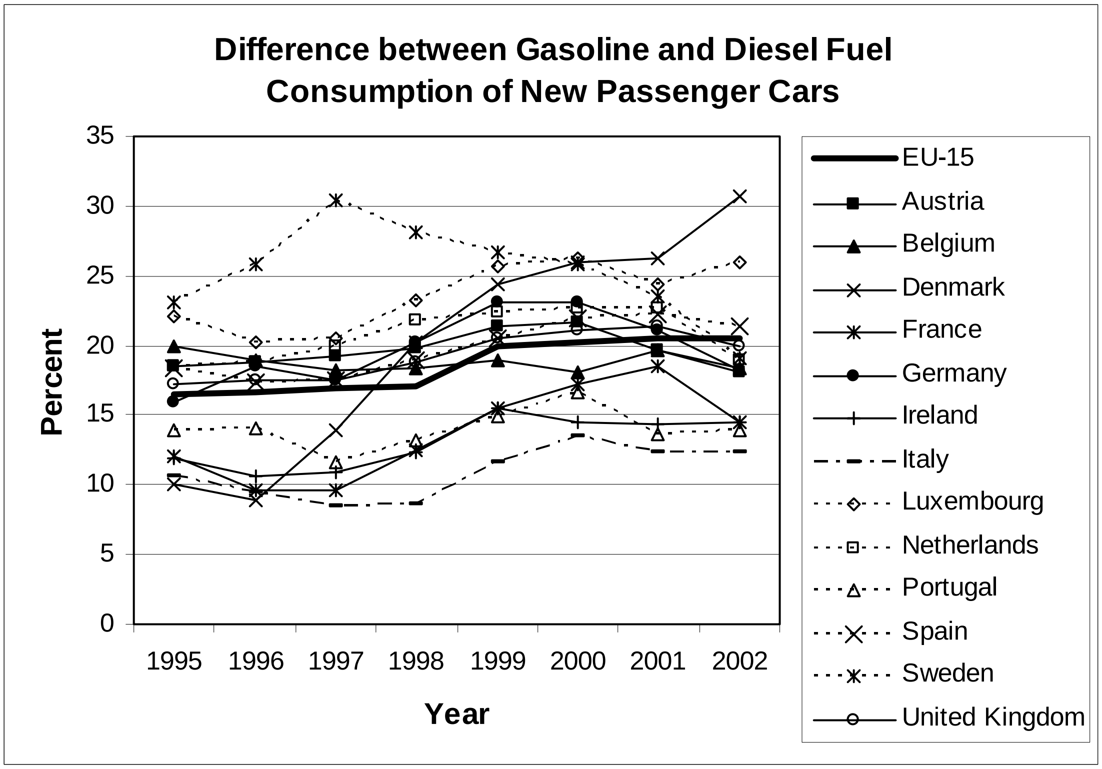

Figure 2.1 Difference in fuel consumption of new passenger cars

Percent difference in diesel vehicle fuel consumption from gasoline consumption, e.g. in the EU the average new diesel vehicle consumed 16-21% less fuel than the average new gasoline vehicle.

(Sources: Monitoring of ACEA's Commitment on CO_2 Emissions Reduction from Passenger Cars 1995-2002, Joint Report of the European Automobile Manufacturers Association and the Commission Services)

kilometer. [10] The fact that this difference is not reflected in most countries—fuel consumption differs by 25% or more in only three countries—indicates that diesel sales are weighted towards larger higher-consuming vehicle models.

In 2002, gasoline vehicles sold in Europe emitted an average of 172g CO_2/km, while new diesel vehicles emitted nearly 10% less (155g CO_2/km), with some recent models emitting as low as 108g CO_2/km[1]. [12] The difference in CO_2 emissions from diesels are not nearly as great as the reduction in fuel consumption, reflecting the higher carbon content of diesel fuel compared to gasoline. As with fuel consumption, CO_2 emissions are weighted by sales. Thus, additional emissions reductions could be achieved by promoting the sale of more efficient vehicles—both gasoline and diesel. However, even a complete shift to diesel vehicles assuming current technologies and sales mix would only provide 40% of the necessary reductions to meet the commitment's targets. Also, some of these reductions would be offset by the increased energy required to produce low-sulfur diesel fuel required to comply with stricter emission standards. [13]

While a shift to diesel vehicles was never envisioned to be the sole strategy for achieving emissions reductions, they have played an important role in the industry's progress to date. Roughly 90% of diesel vehicles sold in 2001 emitted less than 180

[1] Citroën launched their 1.4 C2 in September 2003 claiming 108g CO2/km and a fuel economy of up to 70 mpg. [11. *UK: Small diesel car sales up 25%*, in *Just-Auto.com Daily News Alert*, D. Leggett, Editor. 2003, Just-Auto.com. p. Source: just-auto.com editorial team.]

gCO_2/km (over one-third of sales already meeting the 140 gCO_2/km goal) compared to only about 65% of gasoline vehicles falling into that category (less than 15% meeting the commitment target). [14] Nearly 20% (7.9g CO_2/km) of the 25% reductions called for in the voluntary agreement is expected to be achieved through widespread diffusion of diesels. [8] However, the reductions from diesels result not only from the change in fuel type but also from greater efficiency improvements of diesel technology compared to gasoline vehicles. [15]

Automaker R&D

European automakers are currently devoting half of their research and development expenditures to CO_2 efficient technologies. [16] The European Council for Automotive Research and Development, EUCAR, is a strategic cooperation of European automakers for technological innovation. In 1998, EUCAR launched 'CO2perate' specifically to research CO_2 emissions reductions technologies within the constraints of safety, affordability, and consumer acceptance. The program is funded through 2004 at 300 million EUR, with funding split mostly between the EU and the industry. [17] Research is directed toward powertrain development of traditional combustion engines and hybrid electric and fuel cell vehicles, light weight materials, and improved efficiency of electronics and vehicle control systems. The EUDIESEL project, a joint venture of automakers, suppliers, and universities, aims to develop a direct injection diesel passenger car with improved air pollutant emissions, while still maintaining the fuel economy of most diesels. Such vehicles would combine high-pressure fuel injection, electronic valve control, and homogeneous charge compression ignition to reduce NO_x and particulates.

These internally and cooperatively funded R&D investments have proven successful as manufacturers have been able to develop and introduce new and improved technologies on a large scale, producing early emissions reductions beyond their expectations. [15] The use of diesel engines and fuels is playing a key role, but automakers are also developing and introducing a variety of other efficiency-improving technologies, including turbochargers, high pressure direct injection systems for gasoline as well as diesel engines, new transmission systems, starter-alternators, electric steering, and improved air-conditioners. [16] ACEA expects that direct injection engines, for both gasoline and diesel engines, will comprise 90% of the new vehicle market by 2008. [18] The European manufacturers have less experience with hybrid drivetrains than the Japanese, and have chosen to focus on diesels to achieve CO_2 reductions. However, EUCAR's Surplus Value Hybrid (SUVA) program hoped to have a marketable hybrid available in 2004, though they have yet to announce any significant progress towards this goal to date.

European emission standards

European automakers' strategy to pursue light-duty diesel vehicles was enabled by favorable emission standards. Unlike the United States where light duty gasoline and diesel vehicles must comply with the same air pollution regulations, diesels in Europe are subject to different standards than gasoline vehicles. Current and future emission standards in Europe are detailed in Table 2.1. Under the conditions of the industry's agreement, these standards are not likely to be further tightened before 2008. In an uncontrolled state, diesel engines emit less carbon monoxide and hydrocarbons than gasoline engines, but more nitrogen oxides and particulate matter. Dramatic progress has been made in the past few years in reducing particulate emissions from diesel engines, and future diesel engines are expected to have particulate emissions comparable to those of gasoline engines. However, current Euro 3 standards for particulate matter emissions from diesel vehicles are more than eight times higher than US Tier 2 standards on a per-kilometer basis, and also less stringent in that they apply only for 80,000 kilometers, versus 193,080 kilometers for US standards.[2] This discrepancy is reduced somewhat by Euro 4 standards that take effect in 2005, but even then the standards will still be about four times higher for diesel vehicles than US Tier 2 standards – and for only 100,000 km.[3]

Reduction of nitrogen oxide emissions from diesel engines has proven far more difficult and costly. Current EU standards allow diesel cars to emit roughly three times more oxides of nitrogen than gasoline engines, and upcoming Euro 4 standards are almost six times less stringent for diesel vehicles than US Tier 2. For gasoline vehicles, European standards are about two times less stringent than US standards. In this case of NOx emissions, diesel's preferential treatment is critical. If diesel vehicles were required to meet the same low level of NOx emissions as gasoline cars, the additional cost would be substantial. [19]

Table 2.1 European Vehicle Emission Standards (grams per kilometer)

		Carbon Monoxide		Hydrocarbons		Oxides of Nitrogen		Particulates
		Diesel	Gasoline	Diesel[1]	Gasoline	Diesel	Gasoline	Diesel
Euro 3[2] (2000)	PC	0.64	2.3	0.06	0.20	0.50	0.15	0.05
	LT[4]	0.64-0.95	2.3-5.22	0.06-0.08	0.20-0.29	0.50-0.78	0.15-0.21	0.05-0.1
Euro 4[3] (2005)	PC	0.50	1.0	0.05	0.10	0.25	0.08	0.025
	LT[4]	0.50-0.74	1.0-2.27	0.05-0.07	0.10-0.16	0.25-0.39	0.08-0.11	0.03-0.06

[1] Hydrocarbon limits for diesels calculated by subtracting NOx limit from combined hydrocarbon and oxides of nitrogen limit; no standards exist only for hydrocarbons.
[2] Euro3 standards apply for a useful life of 80,000 km
[3] Euro4 standards apply for a useful life of 100,000km
[4] Light truck values represent the range for Classes I, II, and III (Reference Mass RW<1305kg, 1305kg<RW<1760kg, RW>1760kg)
(Source: [1])

Vehicle Costs and Pricing

Although diesel vehicles do indeed emit less CO_2, automakers presumably would not pursue diesels as a CO_2 reduction strategy without a sound business case—particularly since at present the agreement is voluntary and each manufacturer is free to develop a range of technological options. One may therefore conclude that the recent success of diesels is in part due to their profitability and not just their CO_2 savings. Diesel sales have been so strong that recently demand has been exceeding supply. Both Renault and PSA/Peugeot-Citroen attributed lost sales in 2001 to a lack of diesel engines. Managing director of Automobiles Citroen said, "We could have made more sales if our

[2] Note that the US and EU use different test cycles to obtain vehicle emissions levels.
[3] US Tier 2 and California LEV2 standards no longer are uniform numbers but include a range of emission level "bins" that vehicles can be certified at, but each automaker must still meet average standards for its fleet.

diesel engine production had been up to it." In fact, Renault halted assembly at two plants in 2002 due to the shortage of diesel engines rather than accumulate gasoline vehicles. [20]

Diesel vehicles do have higher production costs than their gasoline counterparts. Diesel vehicles must be built to withstand a higher compression ratio which adds to both vehicle weight and material costs. Most diesel vehicles are also equipped with turbochargers, sophisticated direct-injection systems, and emissions control equipment such as particulate traps and regenerative filters that may not be installed in gasoline vehicles. Major automotive suppliers such as Bosch, Siemens, and Delphi have been competing to supply diesel engine components to the expanding diesel car market. [21]

A direct comparison between diesel and gasoline vehicles is not straightforward. But in a sample of 41 pairs of diesel and gasoline vehicles, Verboven found the average wholesale replacement cost of a diesel engine to be $586 more than a gasoline engine. Meanwhile, the difference in vehicle prices averaged $1567. [22] Based on this observation and the results of a consumer demand model, Verboven estimates that only 10-25% of the price premium for diesel vehicles can be attributed to their higher production costs. [22] The remainder of the difference is due to firms discriminating between consumers traveling high and low-mileage, essentially charging more to consumers valuing fuel economy. The amount of the premium depends on fuel costs, which in turn vary by country. Table 2.2 details the variation in vehicle prices in the fifteen EU countries for a single popular-selling model. (Note that this table is only intended as an illustrative example of price variations and may not represent all vehicles on the market.) In almost all cases, diesel vehicles are priced 800-6040 EUR higher than gasoline vehicles of equivalent performance (as measured by horsepower), suggesting that the additional costs are passed on to consumers, often with significant profit to the automaker.

Table 2.2 Price of Peugeot 307, Gasoline and Diesel Models, Taxes Included

Vehicle Price w/tax (EURO)	2.0 HDi (90 bhp) Diesel	1.6 (110 bhp) Gasoline	Price Difference for Diesels
Austria	19,900	19,000	+900
Belgium	18,760	17,460	+1,300
Denmark	33,266	29,091	+4,175
Germany	16,350	15,550	+800
Greece	NA	16,950	NA
Finland	25,100	21,600	+3,500
France	18,450	16,800	+1,650
Ireland	25,655	22,205	+3,450
Italy	18,650	17,150	+1,500
Luxembourg	17,829	16,594	+1,235
Netherlands	23,710	19,900	+3,810
Portugal	29,015	22,975	+6,040
Spain	18,600	17,090	+1,510
Sweden	16,771	16,771	0
United Kingdom	20,320	19,034	+1,286

EUROS, MODEL YEAR 2003. (Source: www.peugeot.com)

3. CONSUMERS' PERSPECTIVE ON LIGHT-DUTY DIESEL VEHICLES

As essentially the same models of diesel vehicles are offered throughout all the European markets, the variability in diesel sales between countries is best explained by differing consumer preferences and economic incentives. [23] The rise in diesel popularity can be attributed to a number of complementary factors. Much of the recent surge in diesel sales is due to technological advances that have improved vehicle performance. These improvements have changed the common perception of diesels as heavy, noisy, and polluting vehicles while maintaining their fuel economy advantages, making them appealing to a broader range of consumers—not only those looking for sizeable fuel savings such as taxis. [10] At the same time, the price of diesel fuel continues to be about 20% less expensive than gasoline (see Figure 3.1) and the taxation policies in a number of countries favored diesel vehicle purchases. However, the differences in these factors in each country have contributed to the varying growth in diesel vehicle sales.

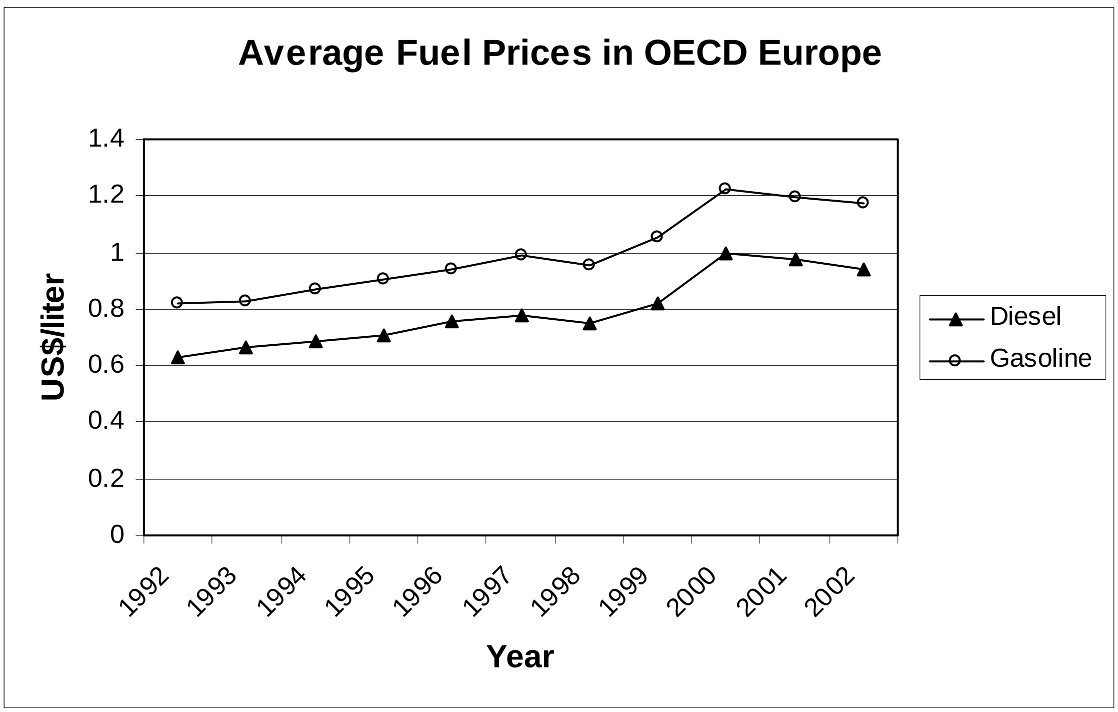

Figure 3.1 Comparison of fuel prices in OECD Europe

Diesel prices are for non-commercial use, gasoline prices are for unleaded (95 RON). Prices are in constant dollars using purchasing power parities.

(Sources: IEA Energy Prices and Taxes 1999: 3rd-4th Quarter and 2003: 2nd Quarter)

Diesel vehicle characteristics

Overall growth in diesel sales is arguably product driven. For the consumer, diesels have provided improved performance without sacrificing fuel savings. While the industry's CO_2 agreement may have motivated manufacturers to invest more heavily in diesel technology, consumer appeal would have been limited without vehicle improvements that made diesel performance comparable to that of gasoline vehicles.

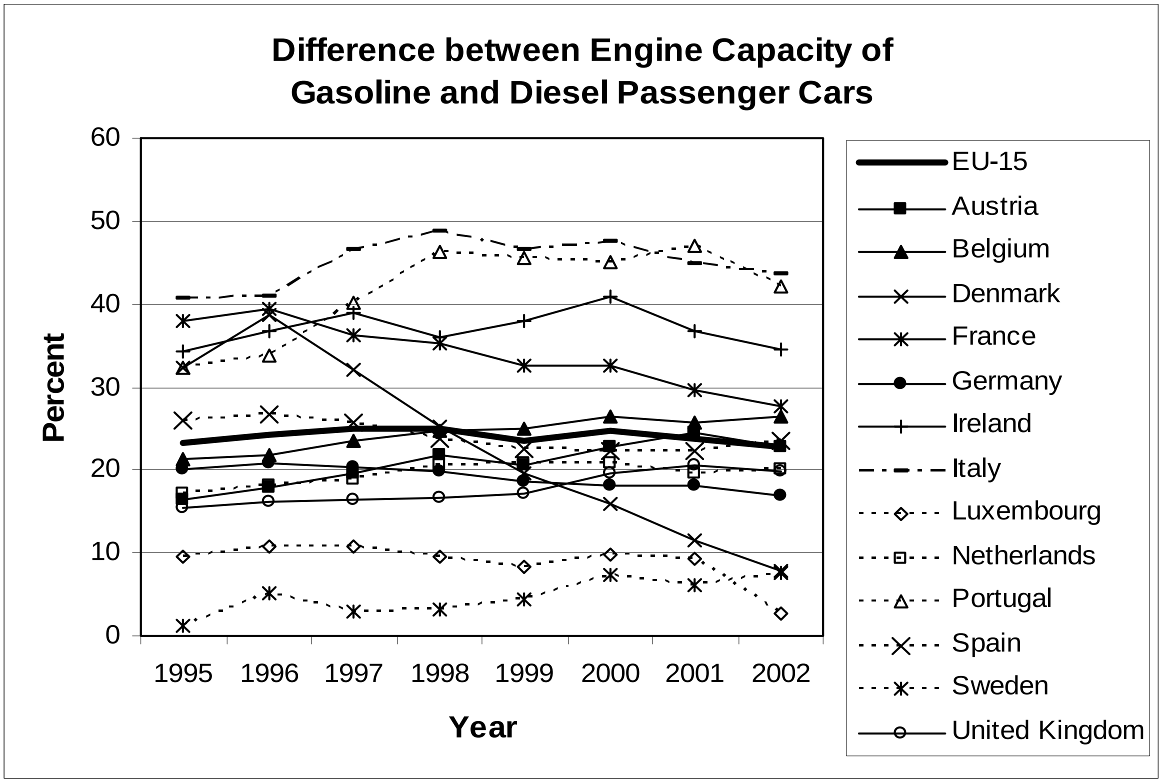

Figure 3.2 Trends in engine size differences for new diesel and gasoline cars
(Sources: Monitoring of ACEA's Commitment on CO_2 Emissions Reduction from Passenger Cars 1995-2002, Joint Report of the European Automobile Manufacturers Association and the Commission Services)

Diesel engines are generally more durable than gasoline ones but also more expensive, larger, and heavier. The added weight results from the fact that a larger sized engine is required to obtain the same performance as a gasoline engine. [10] Though compression ignition engines used in diesel vehicles produce greater torque, they produce lower power for the same engine size. Thus, as shown in Figure 3.2, the engine size of the average diesel vehicle sold is always larger than for the average gasoline vehicle, though this difference varies by country. [15] The wide range is likely due to the sales-weighting, with consumer in some countries favoring the larger, more powerful diesels. However, engine sizes of each type have remained remarkably stable over time within each country. From 1995 to 2001 gasoline engines in Europe grew by only 1.3% and diesels by 1.6%. [15]

Meanwhile, both vehicle weight and power have been increasing steadily. Such trends suggest that vehicles have become more fuel efficient—in part through design improvements in air drag and rolling resistance—but not all of the efficiency gains have translated into fuel savings. [24] The improved efficiency can instead be used to increase the size or performance of a vehicle with no changes to fuel consumption. Diesel vehicle weight has increased 100-200 kg more than the weight of gasoline vehicles since 1995. However, vehicle weight of both fuel types have almost all been increasing since 1995 despite the decrease in fuel consumption and CO_2 emissions. Overall, between 1995 and 2001, diesel vehicles increased in weight by almost 10%. [15] This increase in vehicle weight not only accounts for larger engines but also larger vehicle sizes. Similarly,

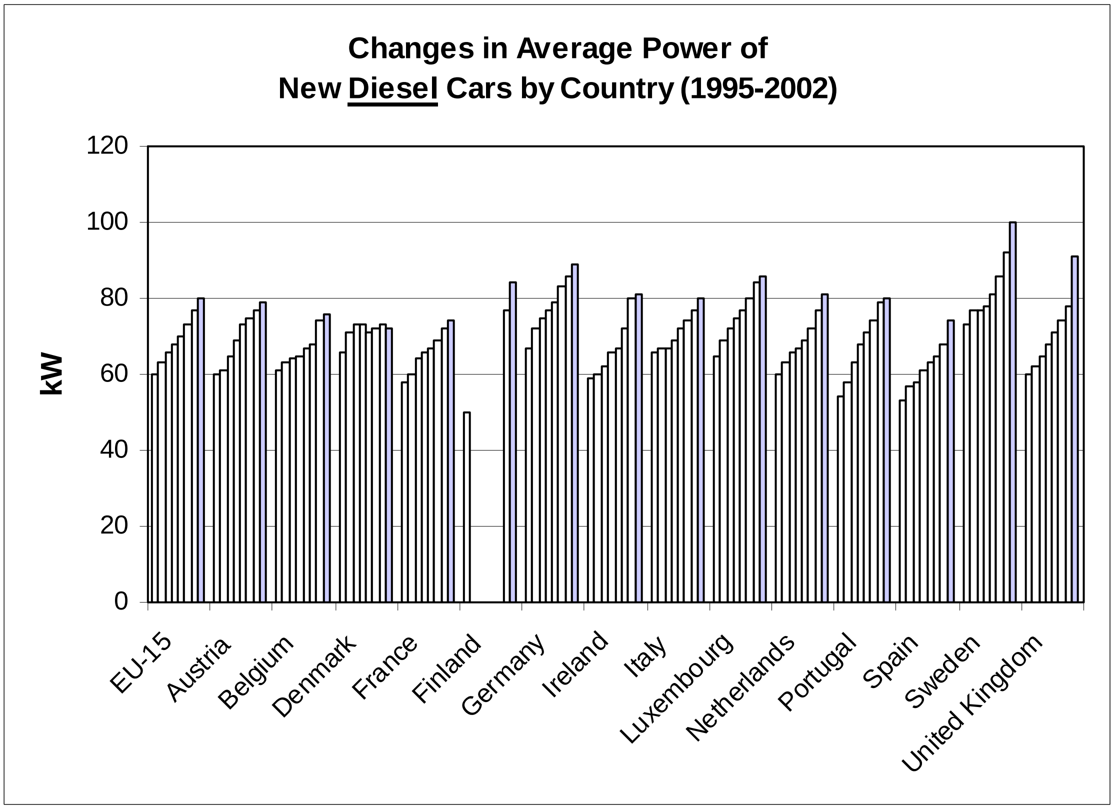

Figure 3.3 Trends in average power of new diesel cars
(Sources: Monitoring of ACEA's Commitment on CO_2 Emissions Reduction from Passenger Cars 1995-2002, Joint Report of the European Automobile Manufacturers Association and the Commission Services)

average power of new diesel vehicles grew by almost 30% between 1995 and 2001, with averages fairly similar between countries. (See Figure 3.3) [15] At the same time, power of the average gasoline vehicle sold has remained relatively constant over time. For diesels, the increased power presumably broadens the vehicle's market, appealing to both luxury markets and small economy vehicle segments. The increase in size and power results from both the introduction of new models as well as incremental increases among existing models as manufacturers continue to distinguish their products from competitors by offering additional power, space, and amenities for the same price. [24] Such improvements in vehicle characteristics have made diesel vehicles more comparable to their gasoline equivalents with the additional benefit of improved fuel economy. However, whether consumer demand or manufacturer marketing is responsible for these trends is unclear.

Potential economic incentives

According to a 1999 survey of motorists in Britain, France, Germany, Italy, the Netherlands, and Spain, 49% of respondents ranked fuel costs as one of their top three concerns regarding road transportation (28% of total respondents ranking fuel costs as their top concern), compared to only 15% for the effect of cars on the environment (3% ranking as their top concern). [25] Thus, the growth in diesel sales from the consumer's perspective seems to relate more to their private costs of vehicle ownership than to the social costs of CO_2 emissions. Diesel vehicles have the potential to offer substantial savings to their owners.

FUEL PRICES. Referring again to Figure 3.1, there is a substantial difference in fuel prices that would favor the sale of diesel vehicles in Europe. The difference between diesel and gasoline fuel prices is largely due to the differences in fuel taxes. With the exception of the United Kingdom where the difference has been slowly eliminated since 1995, diesel is taxed between 13-45% lower than gasoline. (See Figure 3.4) Countries with higher fuel taxes tend to have no or low registration tax, thus using the fuel tax to compensate for the lost revenue. [2] As a result of these fuel tax policies, diesel vehicle owners stand to save significantly in fuel expenditures, especially drivers with high annual driving distances. Consumer choice models typically base fuel type choices on mileage heterogeneity because they assume that consumers have a different willingness to pay for fuel savings. [22] Results of a nested logit model on three groups of vehicles of varying fuel efficiencies indicate that vehicle demand is elastic with respect to operating costs, which mostly consist of fuel costs. [26] Thus, a rational consumer would choose to purchase a diesel when the higher fixed initial costs of the vehicle can be offset by the lower operating costs in the long run.

Returning to the prior illustrative example of the Peugeot 307 shows the potential benefit of diesel vehicles to consumers between countries (See Table 3.1). Assuming that the diesel and equivalent gasoline versions were driven the same distances per year in a

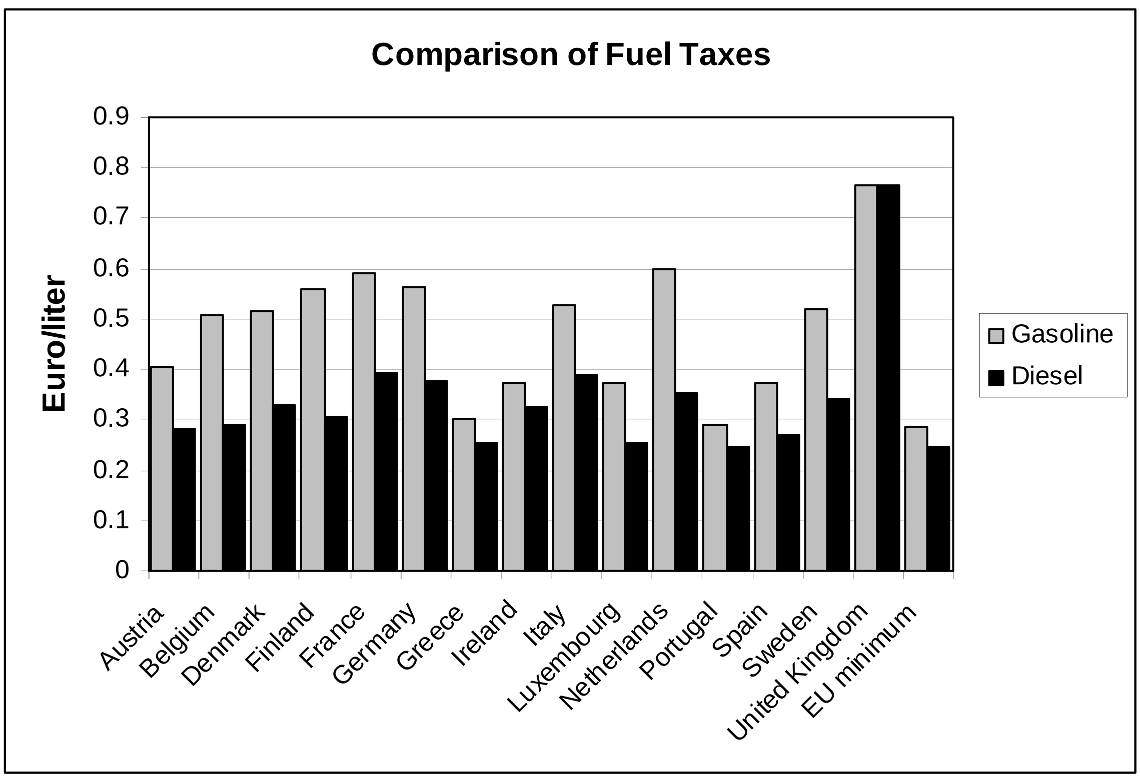

Figure 3.4 Comparison of diesel and gasoline fuel taxes (2000)
(Source: [27])

Table 3.1 Comparison of Consumer Benefits for Peugeot 307, Gasoline and Diesel Models

Country	(A) Price Difference for Diesels	(B) Diesel Fuel Savings (US$/yr)	(C) Payback Period (yrs)	(D) Passenger-Miles per capita (yr)	(E) Diesel Savings (miles)
Austria	+900	218	4.1	5308	4340
Belgium	+1,300	293	4.4	6520	5280
Denmark	+4,175	264	15.8	6790	4651
Germany	+800	172	4.7	6823	4132
Greece	NA	208	NA	7634	4433
Finland	+3,500	216	16.2	5320	4166
France	+1,650	123	13.4	4781	2377
Ireland	+3,450	213	16.2	5628	3660
Italy	+1,500	199	7.5	7147	4605
Luxembourg	+1,235	384	3.2	7281	7153
Netherlands	+3,810	181	21.0	5884	3744
Portugal	+6,040	203	29.8	5387	4494
Spain	+1,510	200	7.5	4722	3665
Sweden	0	236	0	6498	4223
United Kingdom	+1,286	162	7.9	6473	1923

given country (Table 3.1, Column D[4]), the diesel version could save consumers between \$123 to \$384 per year in fuel expenditures based on the vehicle's fuel economy and the country's fuel prices (Table 3.1, Column B). Using the simple formula of dividing the incremental price of the diesel (Table 3.1, Column A) by the annual fuel savings yields the payback period for the consumer's initial investment for improved fuel economy. Note that more sophisticated payback periods typically involve discounting and other considerations, however based on the work of Kurani and Turrentine (2004, see their report as part of this contract) most consumers do not consider these factors in this much depth, if at all. Column C of Table 3.1 shows that the payback period ranges from 0 to almost 30 years. Countries with shorter payback periods tend to have a greater market share of diesel vehicles. Given that consumers may be thinking more about their annual mileage than the payback period, Column E converts the fuel savings from dollars into miles. Thus, for the same annual fuel expenditure of the gasoline vehicle, in many cases the diesel version could be driven nearly twice as much.

In reality, though, owners of diesel vehicles may not actually be spending less on fuel. Schipper et al. found that despite the improved fuel economy of diesel vehicles, they do not necessarily result in net fuel or CO_2 savings *per vehicle* given that they are driven longer distances. [10] In Italy, the Netherlands, and the United Kingdom, annual

[4] Note that these are passenger-miles per capita and not per vehicle. However, this example is only intended to show the variation between countries and the potential benefit to consumers. The variation in passenger-miles between countries can be due to multiple factors such as vehicle ownership levels, urban form and density, and availability of public transit. (Source: Passenger-miles per capita for 2001. ENERGY & TRANSPORT IN FIGURES, Statistical Pocket Book 2003. European Commission)

fuel expenditures were higher for diesel vehicles than gasoline vehicles and about equal for both fuel types in France (based on 1995 fuel prices). On average, gasoline vehicles are driven substantially less than their diesel counterparts. [22] In a sample of five European countries, average annual distances per diesel vehicle in 1995 ranged from 42 to 113 percent greater than the average for gasoline vehicles. However, the extent to which this difference can be attributed to a rebound effect is unclear. Empirical evidence presented by Hivert (1994, as cited in [10]) indicates that some rebounding occurs: drivers switching from gasoline to diesel vehicles increased their travel by 3500 km while drivers switching in the other direction decreased their travel by 6000km.[5] The rebound effect does not account for the entire difference in mileage, though. Self-selection likely accounts for a large portion of this difference as those drivers who anticipate driving greater annual distances will consider the operating costs of their vehicle purchase more carefully. A portion of these purchases may in fact be as company cars that are intended for high-mileage driving. Another confounder influencing the difference in annual vehicle kilometers traveled is that mileage will be redistributed with a household fleet to favor the more fuel economic vehicle. Diesels may also be favored because on average diesel vehicles are newer than gasoline vehicles; overall, newer vehicles tend to be driven more than older ones.

VEHICLE TAXES. In addition to the standard value added tax (15-25%) required in all EU countries, new car buyers in ten of the member countries are also subjected to a one-time registration tax at the time of purchase. Those countries without registration taxes generally have large vehicle car industries. These tax rates are widely varied between countries, ranging from as little as 267 EUR in Italy to as much as 15659 EUR in Denmark. [2] In seven of the ten countries, the rate is based upon the sale price, in some cases further differentiated by engine size, fuel type, or fuel consumption; two countries base the tax solely on engine displacement and the final country has a flat tax. Manufacturers thus tend to price vehicles lower in high-tax countries so that the consumer's final cost of purchasing a new car is relatively uniform across countries. However, diesels will still generally be more expensive than their gasoline counterparts, in part because they are subjected to higher taxes either explicitly based on fuel type or indirectly based on vehicle attributes. The higher registration taxes for diesel vehicles have been included in the price difference and payback period calculation, which contributes to some of the variation between countries.

Vehicle owners are also responsible for annual circulation (ownership) taxes. In general, countries with high registration taxes tend to have relatively lower circulation taxes. With the exception of France where taxes are determined regionally, all Member States impose a national circulation tax. Annual taxes range from 14 EUR for small vehicles in Portugal to 2,272 EUR for gas guzzlers in Denmark. [27] Average annual taxes are typically concentrated within the 100-500 EUR span. [2] Similar to registration taxes, the ownership tax bases vary from engine size, power, and weight to fuel consumption or CO_2 emissions. In almost all countries, though, diesel vehicle owners pay higher circulation taxes to compensate for the reduced fuel tax revenue. For diesels, the higher circulation taxes could feasibly eliminate their annual fuel savings.

[5] A more thorough analysis on the rebound effect is underway by researchers at UC Irvine and therefore will not be discussed here further.

These additional costs play an important role in a consumer's purchasing decision in that consumers consider the entire cost of vehicle ownership to which vehicle taxes may contribute significantly. [22] Recently, tax incentives have been created for low CO_2-emission vehicles in some countries. Beginning in 2001, ownership taxes in the United Kingdom became based on CO_2 emissions, with vehicles emitting less than 150 g CO_2/km charged paying more than one-third less the tax (159 EUR) than those vehicles emitting more then 185g CO_2/km (246 EUR). [27] Though diesel vehicles are taxed an additional 15 EUR, this taxation policy would still moderately favor diesel sales. In Germany, circulation tax exemptions are offered for vehicles meeting low air quality and CO_2 emission targets. Similarly, Austria bases its registration tax based on fuel consumption, exempting the most efficient vehicles from the tax. In Denmark, registration taxes will be reduced by between one-sixth and two-thirds depending on the vehicle's fuel consumption. However, diesel vehicles are subject to a slightly more stringent standard than gasoline vehicles for the same tax reduction. [27]

Other potential consumer considerations

A host of other factors maybe also be influencing consumers during their vehicle purchase decision. From the supply perspective, the proliferation of models available as diesels would broaden their appeal to prospective buyers. Markets dominated by manufacturers more aggressively pursuing diesels would thus be expected to exhibit larger growth in diesel sales. Consumers in different regions of Europe may also have different requirements for their vehicles. For instance, mountainous areas might favor diesels for their increased torque at lower speeds while colder climates might discourage them due to slower start times in cold weather. At an even smaller scale, residents in congested urban areas often prefer diesel vehicles given their improved fuel economy and lower operating costs. [26] Cultural and educational differences may impact the extent to which consumers view global climate change, oil dependency and air pollution as problems. In addition, vehicle demand would be influenced by population demographics. [24] Income in particular would affect both the type of vehicle purchased and the intensity with which it is driven. Vehicle usage, an important criterion in consumer choice models, is also impacted by road investments, urban density/decentralization, and the quality of public transit.

4. EXPLAINING THE DIFFERENCES IN LIGHT-DUTY DIESEL VEHICLE SALES

Overall, sales of diesel vehicles in the EU have roughly doubled between 1994 and 2002, with much of the growth occurring in the latter years. (See Figure 4.1) In 2003, Italy joined France, Spain, Austria, Belgium and Luxembourg to become the sixth European country where diesel vehicles outsold gasoline models. For Europe overall, diesel sales reached a new record in 2003 capturing 44% of the new car market. [28] In contrast, diesel sales in the United States peaked in 1981 at 5.1 percent and have not exceeded 1 percent since 1985. [29] With the exception of England, diesel penetration continues to increase in all major markets. [30] However, the sales volume of diesel vehicles has not been uniform across European countries. (See Figure 4.2)

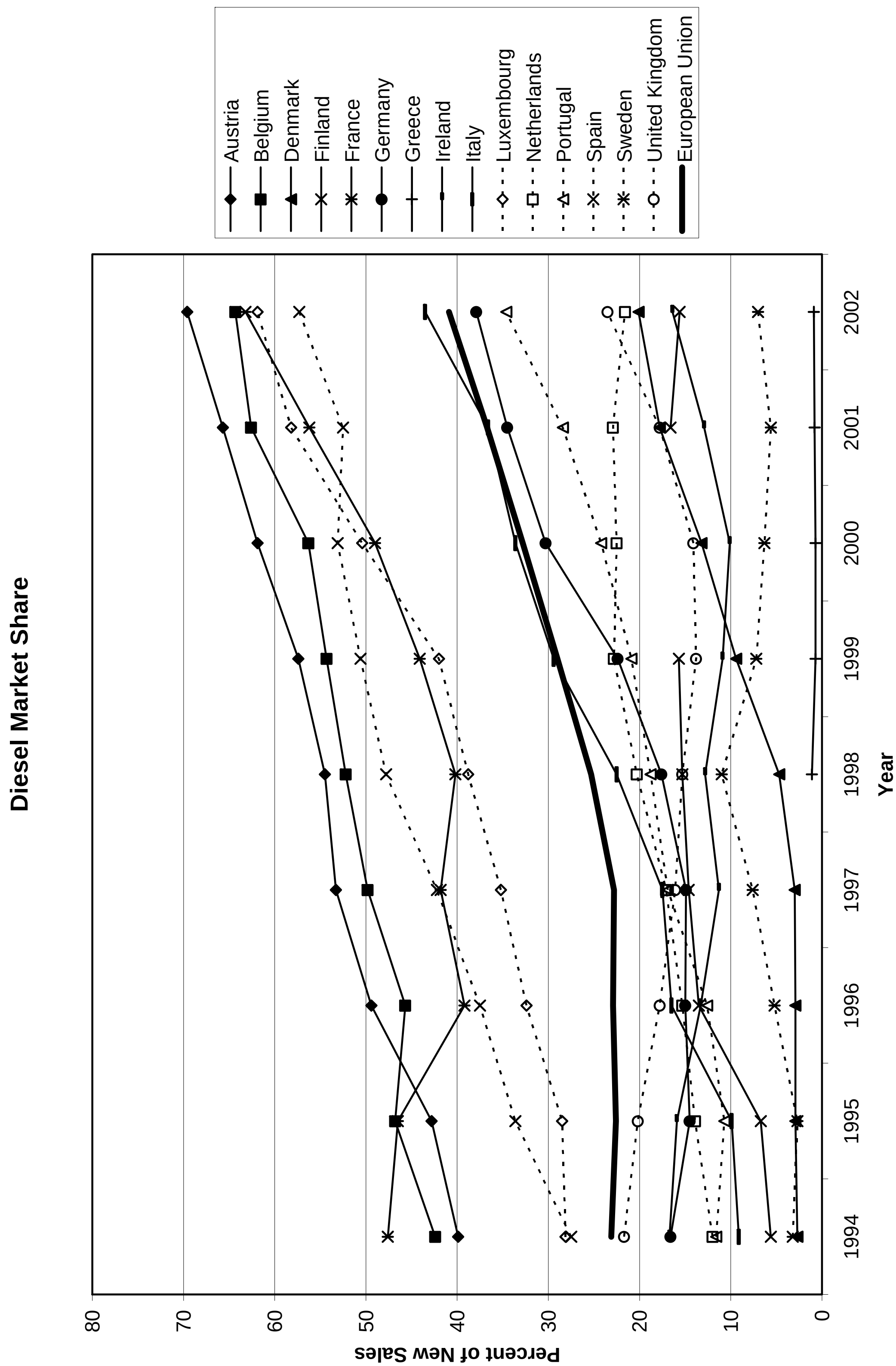

Figure 4.1 Diesel share of new vehicle sales (Source: ACEA)

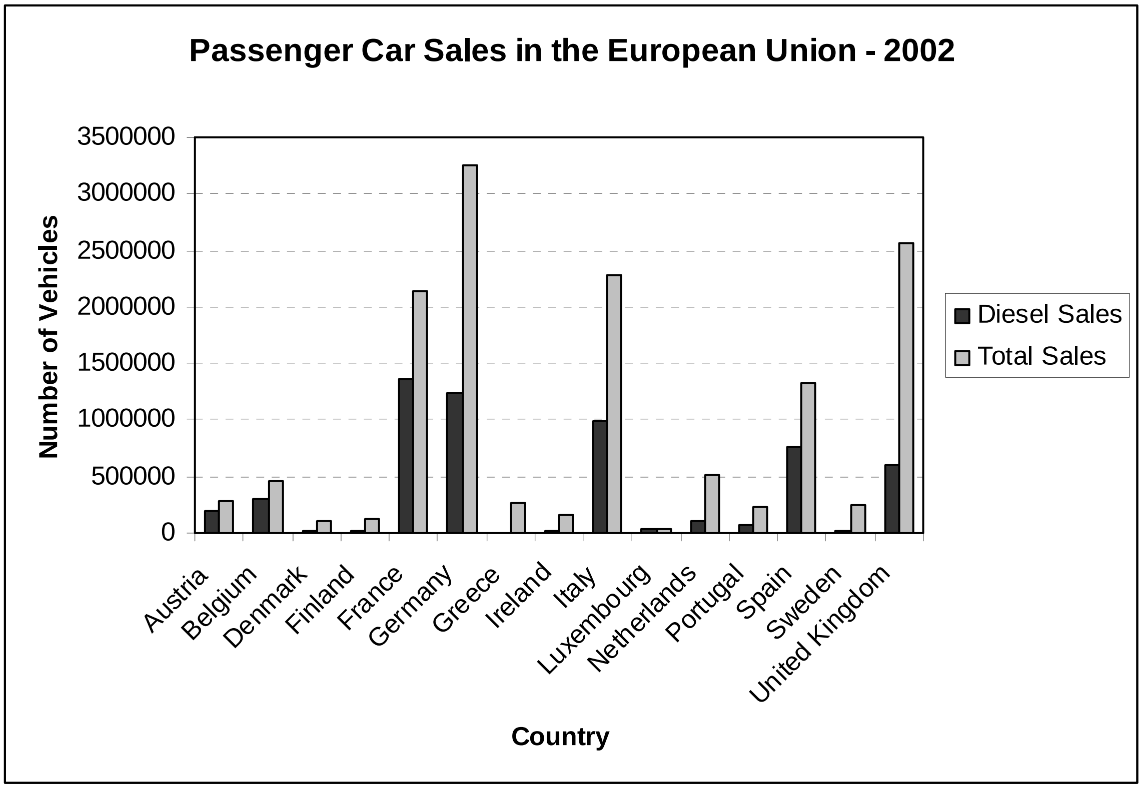

Figure 4.2 Diesel sales volumes in 2002 (Source: ACEA)

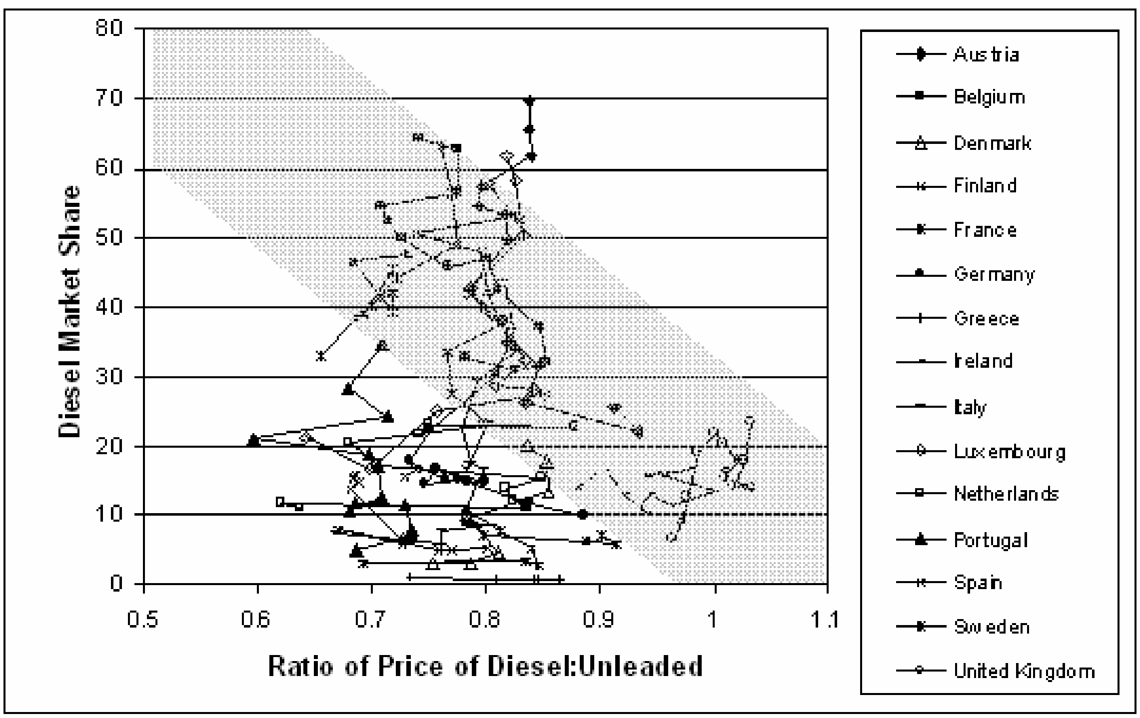

Figure 4.3 Comparison of diesel:gasoline price ratio and market share of new diesel vehicles (1992-2002)

Diesel prices are for non-commercial use, gasoline prices are for unleaded (95 RON)
(Sources: IEA Energy Prices and Taxes 1999: 3rd-4th Quarter and 2003: 2nd Quarter)

The variability in tax levels on fuels and vehicles is the primary factor explaining the differences in diesel sales between countries. [23] For countries that have experienced the most growth, fuel prices do appear to be a motivating determinant. Lower diesel fuel prices offer the potential for substantial savings. Likewise, in some countries where diesel has a minimal price advantage, diesel vehicle sales are accordingly low. However, if diesel market share was solely explained by the fuel price advantage, the curves in Figure 4.3 would all be expected to fall within the shaded area where diesel sales are high when diesel fuel is much less expensive than gasoline and sales are low when the fuels are more evenly priced.

Clearly other forces are at work for countries where diesel fuel is priced appreciably lower than gasoline but diesel sales remain limited. The price premium for a diesel varies by country, as does the vehicle registration tax which effectively increases the purchase price of the vehicle. In some cases, the potential fuel savings may not offset the necessary initial investment of purchasing a diesel vehicle. Additionally, the annual circulation taxes may completely eliminate the fuel cost savings, which would discourage sales of diesels in certain countries. Tax policies may also work in the opposite direction, though, to provide incentives for diesel purchases in the absence of a significant fuel price advantage.

Table 4.1 Comparison of diesel market share in 2002 to fiscal/economic factors

	Market Share	Price Ratio	Registration tax favors:	Ownership tax favors:
Austria	69.6 (1)	0.84 (11)	Diesel	Diesel
Belgium	64.3 (2)	0.74 (4)	Gasoline	Gasoline
Denmark	20.1 (11)	0.84 (11)	Gasoline	Neutral
Finland	15.6 (13)	0.73 (2)	Gasoline	Gasoline
France	63.2 (3)	0.76 (5)	NA	NA
Germany	37.9 (7)	0.82 (9)	NA	Gasoline
Greece	0.9 (15)	0.85 (12)	Gasoline	Gasoline
Ireland	16.4 (12)	0.91 (14)	Gasoline	Gasoline
Italy	43.5 (6)	0.82 (9)	Neutral	Diesel
Luxembourg	61.9 (4)	0.82 (9)	NA	Gasoline
Netherlands	21.6 (10)	0.74 (4)	Gasoline	Gasoline
Portugal	34.6 (8)	0.71 (1)	Gasoline	Gasoline
Spain	57.3 (5)	0.80 (6)	Gasoline	Gasoline
Sweden	7.0 (14)	0.90 (13)	NA	Gasoline
United Kingdom	23.5 (9)	1.03 (15)	NA	Diesel

Ranks of Market Share and Price Ratio shown in parentheses.
(Sources: ACEA, IEA Energy Prices and Taxes 1999: 3rd-4th Quarter and 2003: 2nd Quarter, and COWI)

Table 4.1 summarizes the relationship between diesel sales in 2002 and taxation policies between countries. If market share were determined solely by the difference in price of diesel fuel and unleaded gasoline, the market share and price ratio ranks would be expected to match. In Belgium, France, Germany, Italy, and Spain low diesel fuel prices relative to gasoline prices appear to be encouraging diesel sales despite tax policies favoring gasoline vehicles. Similarly, in Denmark, Greece, Ireland, and Sweden higher diesel fuel prices are discouraging the sale of diesels, though tax policies may be reinforcing the effect of fuel prices.

However in the remaining countries, the taxation policies are the dominating driver behind determining market share. In Austria, registration taxes are lower for more fuel economical vehicles while ownership taxes are based upon vehicle power (kW), both of which favor diesels. Thus, despite relatively more expensive diesel fuel compared to other European countries, Austria has long been the leader in diesel sales due to its favorable tax polices. Similarly, despite diesel fuel being more expensive than gasoline, diesel sales in the United Kingdom are also higher than expected as a result of a new ownership tax based on CO_2 specifically. The opposite effect is observed in Finland, the Netherlands, and Portugal where diesel market shares have been limited even though the price ratio between diesel and gasoline is relatively favorable. In Finland and the Netherlands, ownership taxes are based on weight but differentiated by the vehicle's fuel type. Thus, in the Netherlands, a diesel vehicle is taxed 283% higher than a gasoline vehicle of the same weight; in Finland diesel owners pay a weight-based tax but gasoline vehicle owners pay a flat (and generally lower) tax. Ownership taxes are also differentiated by fuel type in Portugal though based on engine capacity instead of weight. Drivers in these countries may not reach the breakeven vehicle kilometers traveled for the fuel cost savings to exceed the additional expense of owning a diesel vehicle. The higher vehicle taxes on diesels appear to be the reason Portugal has experienced only moderate growth in diesel vehicle sales despite having the most favorable fuel price ratio in the EU.

Such fiscal measures appear to have a significant influence on diesel shares, which could play an important role in achieving the European Commission's goal of reducing emissions from new vehicles to 120g CO_2/km.

5. SUMMARY AND CONCLUSIONS

Light-duty diesel vehicles in Europe have experienced tremendous popularity. Spurred by the auto industry's voluntary agreement to reduce CO_2 emissions, diesel technology has improved greatly so that new vehicles offer increased power and size while maintaining engine capacity and even improving fuel economy. Although these technological advances may improve the consumer's perception of diesels, taxation policies in the Member States vary widely and play a pivotal role in diesel sales.

In the case of Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Spain, and Sweden, favorable tax treatment of diesel fuel dominates other effects, with market shares roughly correlated to the price of diesel fuel relative to gasoline. In the remaining countries, the market share of diesels is more closely related to the amount of registration and/or ownership taxes paid on the vehicle. For example, looking at the price ratio, one would expect that Austria would have a minimal share of diesels when in fact it is the leader in diesel sales. This result can be explained by registration and ownership tax policies that strongly favor diesel vehicles. Similarly, Finland, the Netherlands, and Portugal would be expected to rank high in diesel sales without tax policies discouraging diesel vehicles. Fiscal measures, together with the voluntary CO_2 agreement between automakers and the EU, clearly play an important role in influencing consumer purchases of new vehicles in Europe – in ways that could reduce CO_2 emissions.

REFERENCES

1. *Vehicle Emissions Reductions*. 2001, European Conference of Ministers of Transport: Paris.
2. *TAXATION OF PASSENGERS CARS IN THE EUROPEAN UNION - options for action at national and Community levels*. 2002, COMMISSION OF THE EUROPEAN COMMUNITIES: Brussels, Belgium.
3. ACEA, *The European Automobile Manufacturers commit to substantial CO2 emission reductions from new Passenger Cars.* July 29, 1998. p. Press Release.
4. Fulton, L.M., *Voluntary Agreements as Drivers of Technological Change in the Transport (Light-duty Vehilce) Sector*. 2000, International Energy Agency: Paris.
5. *Implementing the Community Strategy to Reduce CO2 Emissions from Cars: Fourth annual report on the effectiveness of the strategy (Reporting year 2002)*. 2003, COMMISSION OF THE EUROPEAN COMMUNITIES: Brussels, Belgium.
6. *Belgium: EU and carmalers fail to agree on CO2 emissions objectives*, in *Just-Auto.com Daily News Alert*, D. Leggett, Editor. 2004, Just-Auto.com. p. Source: just-auto.com editorial team.
7. Krix, P., *Study: Emission targets come at high price.* Automotive News, 2003. **78**(6072): p. 18.
8. Kageson, P., *The Drive for Less Fuel: Will the motor industry be able to honour its commitment to the European Union*. 2000, European Federation for Transport and Environment: Brussels, Belgium.
9. *Demand for Diesels: The European Experience*. July 2001, Diesel Technology Forum: Frederick, MD.
10. Schipper, L., C. Marie-Lilliu, and L. Fulton, *Diesels in Europe: Analysis of Characteristics, Usage Patterns, Energy Savings and CO2 Emisssion Implications.* Journal of Transport Economics and Policy, 2002. **36**(2): p. 305-340.
11. *UK: Small diesel car sales up 25%*, in *Just-Auto.com Daily News Alert*, D. Leggett, Editor. 2003, Just-Auto.com. p. Source: just-auto.com editorial team.
12. *Monitoring of ACEA's Commitment on CO2 Emission Reduction from Passenger Cars (2002)*, in *Joint Report of the European Automobile Manufacturers Association and the Commission Services*. 2003, COMMISSION OF THE EUROPEAN COMMUNITIES: Brussels, Belgium.
13. Monahan, P. and D. Friedman, *The Diesel Dilemma: Diesel's Role in the Race for Clean Cars*. 2004, Union of Concerned Scientists: Cambridge, MA.
14. *Implementing the Community Strategy to Reduce CO2 Emissions from Cars: Third annual report on the effectiveness of the strategy (Reporting year 2001)*. 2002, COMMISSION OF THE EUROPEAN COMMUNITIES: Brussels, Belgium.
15. *Monitoring of ACEA's Commitment on CO2 Emission Reduction from Passenger Cars (2001)*, in *Joint Report of the European Automobile Manufacturers Association and the Commission Services*. 2002, COMMISSION OF THE EUROPEAN COMMUNITIES: Brussels, Belgium.

16. *UK: European motor industry struggles with demands for reduced CO2 and noxious emissions*, in *Just-Auto.com Daily News Alert*, D. Leggett, Editor. 2003, Just-Auto.com. p. Source: SupplierBusiness.com.
17. EUCAR, *CO2perate*. 1999. p. http://www.acea.be/EucarInternet/publications/CO2perate99.html.
18. Plotkin, S. *European and Japanese Initiatives to Boost Automotive Fuel Economy: What They are, Their Prospects for Success, Their Usefulness as a Guide for U.S. Action*. in *80th Annual Meeting, Transportation Research Board, January 7–11, 2001*. 2001. Washington, DC.
19. Kliesch, J. and T. Langer, *Deliberating Diesel: Environmental, Technical, and Social Factors Affecting Diesel Passenger Vehicle Prospects in the United States*. 2003, ACEEE.
20. Wright, C. and W.O. Weernink, *Europe's love of diesels is boon to suppliers.* Automotive News, 2002. **76**(5999): p. 22D.
21. Chew, E., *Direct-injection diesels are on a roll; Fuel-economy concerns create demand in Europe.* Automotive News, 1999. **74**(5849): p. 16.
22. Verboven, F., *Quality-based price discrimination and tax incidence: evidence from gasoline and diesel cars.* Rand Journal of Economics, 2002. **33**(2): p. 275-297.
23. Mayeres, I. and S. Proost, *Should diesel cars in Europe be discouraged?* Regional Science and Urban Economics, 2001. **31**(4): p. 453-470.
24. Van den Brink, R.M.M. and B. Van Wee, *Why has car-fleet specific fuel consumption not shown any decrease since 1990? Quantitative analysis of Dutch passenger car-fleet specific fuel consumption.* Transportation Research Part D-Transport and Environment, 2001. **6**(2): p. 75-93.
25. Lawson, S., A. Butler, and E. Downing, *Motorists' concern in six European countries.* Traffic Engineering and Control, 2000. **41**(1): p. 14-6.
26. McCarthy, P.S. and R.S. Tay, *New vehicle consumption and fuel efficiency: A nested logit approach.* Transportation Research Part E-Logistics and Transportation Review, 1998. **34**(1): p. 39-51.
27. COWI, *Fiscal Measures to Reduce CO2 Emissions from New Passenger Cars*. 2002, European Commission's Directorate-General for Environment.
28. *UK: Diesel car sales set new European record in 2003*, in *Just-Auto.com Daily News Alert*, D. Leggett, Editor. 2004, Just-Auto.com. p. Source: just-auto.com editorial team.
29. Hellman, K.H. and R.M. Heavenrich, Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2003. 2003, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. EPA420-R-03-006.
30. Love, M., Diesel Passenger Car and Light Commercial Vehicle Markets in Western Europe. 2001, Ricardo Consulting Engineers Ltd: West Sussex, United Kingdom.

FINAL REPORT

Contract 02-310
Project No. 008545

Analysis of Auto Industry and Consumer Response to Regulations and Technological Change, and Customization of Consumer Response Models in Support of AB 1493 Rulemaking –

The Response of the Auto Industry and Consumers to Changes in the Exhaust Emission and Fuel Economy Standards (1975-2003): A Historical Review of Changes in Technology, Prices, and Sales of Various Classes of Vehicles

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DISCLAIMER

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Abstract

The objectives of this study were to assess the responses of the auto industry and consumers to changes in exhaust emission and fuel economy standards, relate qualitatively these responses to technology developments and changing economic factors, and correlate vehicle sales with vehicle attributes and macro-economic factors. Data regarding the characteristics, prices, and sales of vehicle models from many manufacturers was assembled and analyzed for the years from 1975 to 2003. The analysis indicated that changes in emissions and fuel economy regulations forced the industry to develop an impressive sequence of new and improved technologies that were rapidly introduced in light duty vehicles. Retail prices increased substantially over this time period, with about 1/3 of the increase due to government regulations and 67% due to increased quality of the vehicles. The increase in vehicle prices has been accommodated by increases in disposal income and creative financing of sales through longer loan periods and leasing. Differences were not uniform across vehicle classes. For instance, fuel economy and fuel price appeared to influence sales of midsize and large cars more than small cars. For large cars, engine horsepower was not as significant as fuel economy during the entire time period.

Executive Summary

The objectives of this study were (1) to assess the responses of the auto industry and consumers to changes in the exhaust emission and fuel economy standards that have occurred in the United States and California in the past thirty years (1975-2003), (2) to relate qualitatively these responses to technology developments and changing economic factors, such as vehicle prices, consumer income, inflation, and fuel prices over the same time period, and (3) to correlate quantitatively vehicle sales for the periods 1975-1985 and 1986-2001 for various vehicle classes to vehicle attributes and macro-economic factors using multiple regression analysis. The studies was done to provide information and data to the Research Division of the California Air Resources Board as they consider CO2 emission standards in response to directives in AB 1493 passed by the California Legislature in 2001. The primary thrust of the study was to perform a historical review of what has occurred in the auto industry between 1975-2003 and to assemble a large data base containing the characteristics, prices, and sales of vehicle models from many manufacturers for of the years from 1975 to 2003. The data base was then analyzed using SPSS, ACCESS, and EXCEL software to determine historical trends of vehicle, price, and sales parameters in response to changes in government regulations. The trends are shown graphically and in tabular form in the report. The data in the data base for the various vehicle models and size classes were also analyzed using multiple regression analysis techniques.

The historical review indicated that the changes in emissions and fuel economy regulations forced the industry to develop an impressive sequence of new and improved technologies that were rapidly introduced in passenger cars, vans, SUVs, and light duty trucks starting in about 1976. The result has been gasoline fueled, light duty vehicles with ultra-clean emissions (ULEV and SULEV) and improvements in fuel economy of 60-75% relative to comparable 1975 models. The MSRP prices (2001$) of the models in the various vehicle classes have increased between 1975-2001 by a factor of 1.5 to 2.0 based on the general consumer price index (cpi). The sales-weighted average MSRP price of vehicles has increased over the same period by 46% (a factor of 1.46). Of that increase 33% of the increase is due to government regulations and 67% is due to increased quality of the vehicles. The price analyses indicated that the actual prices of cars of constant quality increased slower in the period of interest than the general price index. If that had not been the case, the average price of cars between 1975 and 2001 would have increased by 73% rather than 46% in constant 2001$. The fuel economy of the new vehicles reached a peak in about 1987 and the fleet fuel economy for new vehicles has actual gone down as the sales of vans and SUVs has increased until in 2001 total sales of vans and SUVs are about the same as passenger cars. Total vehicles sales have been between 13-17 million annually since 1984 with most of the year-to-year fluctuation due to changes in the economic conditions. The increase in vehicle prices has been accommodated by increases in disposal income and creative financing of sales through longer loan periods and leasing. Vehicle sales have remained high in periods of favorable economic conditions through periods of significant changes in government regulations.

1. Introduction

This report is concerned with assessing the response of the auto industry and consumers to changes in exhaust emission and fuel economy standards since 1975. During the period 1975-2004, the emission standards, especially for passenger cars, have been tightened markedly in both the United States and California and the fuel economy (CAFE) standard was increased from 18 to 27.5 mpg from 1977-1985. These changes in the regulations have resulted in large changes in the technology incorporated into vehicles presently being marketed by the auto companies compared to vehicles marketed in 1975. The technology changes were introduced over the years as needed to meet the changing regulations. It is of interest to track historically the effect of these technology changes on the characteristics (size/weight, acceleration, and fuel economy), price, and sales of various classes of vehicles as a means of projecting how the auto industry and consumers would likely respond to possible future changes in regulations that would require significant reductions in CO2 emissions.

There are data available from many sources that are appropriate for this study and a relatively large fraction of the data is available over the internet making it relatively easy to transfer it into a single data base for analysis. Hence in the initial part of this study, a large data base was assembled that included technology, performance, emissions, fuel economy, price, and sales data for many of the vehicle models marketed by most of the auto companies in the world during the period 1975-2003. Much of the effort in the study was concerned with the analysis of this data using SPSS, ACCESS, and EXCEL software to determine the historical trends of the vehicle, price, and sales parameters in response to changes in the regulations and technology. These trends are shown graphically and in tabular form in the various sections of the report that follow.

1.1 Literature Review

A large body of literature is available that examines the many issues surrounding government regulation of the automobile industry. Gerard and Lave (May 2003), for example, argue that regulations stemming from the 1970 Clean Air Act led to significant technological changes and environmental improvements. There are many other studies that focus on the technology forcing nature of automotive industry regulation, particularly with respect to emissions control, and to a lesser extent, automobile safety (e.g. airbags). The CAFE standards are not, strictly speaking, a technology-forcing policy since automakers could meet the requirement through changes in the mix of vehicles offered. Three essays in a 1999 collection of essays (Gomez-Ibanez, 1999) on the topic of transportation economics and policy investigate three important aspects of government regulation and the auto industry. These include “The Politics of Controlling Auto Air Pollution” by Howitt and Altshuler, “Fuel Economy and Auto Safety Regulation: Is the Cure Worse than the Disease?” by Charles and Lester Lave, and “Technology-Forcing Public Policies and the Automobile” by Leone. Howitt and Altshuler discuss policy instruments intended to control auto emissions, and in the ‘future implications’ section of their paper, discuss the applicability of past regulations to future greenhouse gas emission policies. The Laves conclude that Federal legislation and regulation of automobiles focus almost exclusively on an immediate concern, and in the process, ignore possible system effects and behavioral changes. Due to the complex and interdependent nature of the transportation system, the authors believe that ‘solution-caused problems’ should be better anticipated and handled. Leone offers another perspective with special attention paid to technology-forcing regulations. Leone argues that while technology-forcing mandates often achieve positive results, such policy measures should be approached with skepticism to ensure that the use of society's resources is optimized.

A number of books and government reports have emerged over the last 25 years that examine the complex nature of automobile regulation. Some of the more prominent examples include *Regulating the Automobile* (Crandall, 1986), *Corporate Strategies of the Automotive Manufacturers* (Schnapp, 1978), *Use of Advertising and Marketing Incentives to Promote Sales of Fuel Efficient Vehicles* (Donnelly, 1981), *Motor vehicle regulations (1992): Regulatory cost estimates could be improved* , *Assessing regulatory impacts (1981): The Federal experience with the auto industry*, *Cleaner Cars: The History and Technology of Emission Control Since the 1960s* (Mondt, 2000), and numerous other recordings of Congressional proceedings, Ph.D. theses and books. These sources tend to be dated (i.e. from the late 1970s into the 1980s) because that is the era when these regulations were both contentious and actively being enacted. A number of the more update analyses are identified and discussed in the following sections.

Emissions Control Requirements

Many relevant papers concerning the economic impacts of automobile emissions regulations can be found in the business and economics journal literature. Some notable examples are Bresnahan and Yao (1985, Wang, Kling and Sperling (1993, and Anderson and Sherwood (2002. For a fuller treatment of relevant emissions control literature, see Chen et al.(2003).

Safety and Occupant Protection Standards

Papers that deal with the economic impacts of occupant crash protection include Graham (1984), Gomez-Ibanez (1997), Mannering and Winston (1995), Peltzman (1975), Arnould and Grabowski (1981), Dunham (1997), and others. These papers examine costs and benefits and compliance costs, as well as offsetting behavior and societal costs. For a complete literature review of the relevant airbag and passive restraint literature, see Abeles et al.(2003).

CAFE Standards

CAFE standards have been the object of intense scrutiny by economists and other policy analysts since they were first adopted. In 1981, Gsellman (1981) questioned whether the 1981-84 standards could be achieved (Reference 20a). McNutt (1983) discusses the consumption effects achieved through U.S. fuel economy policy prior to 1983. Many economists have argued that CAFE only became a binding constraint on auto manufacturers after gasoline prices fell in the 1980s from a peak of $2.81 (2001$) in 1982. They concluded that CAFE standards increased when the market alone would have produced greater fuel efficiency because of the high fuel prices. When the CAFE standards stopped increasing in 1985, the sales mix corresponding to what consumers wanted to purchase required manufacturers to produce more fuel-efficient vehicles. (Leone, 1990). Manufacturers were thus forced to make larger price markups for their larger, less fuel efficient (lower mpg) vehicles, and smaller price markups for their smaller, more fuel efficient vehicles (Porter, 1999). A study looking at CAFE standards and their impact on automobile prices for 1978-80 concluded that U.S. automakers initially adopted a strategy of adjusting relative automobile prices to meet the standards, but by the end of the period, automakers were meeting the standards by improving the design of their automobiles to enhance fuel economy, and by a fuel-price driven shift in consumer demand (Falvey,1986). A 1997 study concludes that CAFE standards may have contributed to the decline in average fuel efficiency of the new vehicle fleet by shifting sales toward vans, trucks, and SUVs that met lower CAFÉ standards than passenger cars. (Thorpe, 1997). The less stringent CAFE standards for the larger light-duty vehicles facilitated the large increase in the sales of those vehicles (particularly SUV) from about 20% of total light-duty vehicle sales in 1981 to over 50% in 2001. In 1998, Goldberg used a series of discrete choice models to compare CAFE standards with alternative policies with respect to sales, prices, and fuel consumption (Goldberg, 1998). The results of this study call into question the true achievements of CAFE standards. In 1997, Espey concluded that under current tailpipe emissions standards, increases in fuel economy would increase emissions of the new vehicle fleet and that significantly higher fuel taxes would be required to achieve the same level of pollution reduction (Espey, 1997). A number of other studies have investigated the offsetting costs and benefits of CAFE standards (Crandall, 1989, Dowlatabadi, 1996, Ross, 1994. There is evidence from these studies that supports the claim of offsetting effects that impact vehicle safety and emissions.

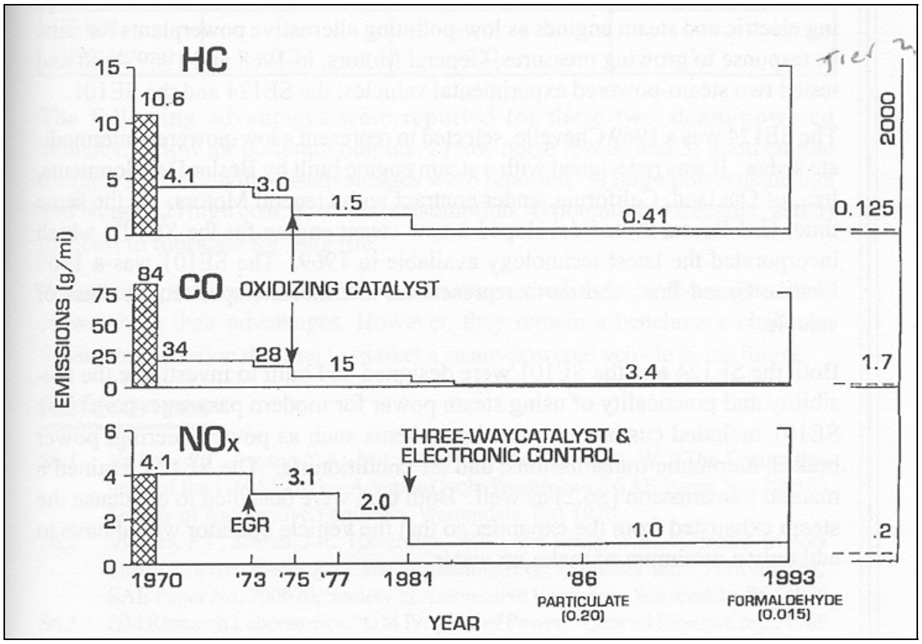
This literature review has indicated that past studies of the relationships between industry and consumer responses have been more narrowly focused than the study undertaken in the present project and for the most part were completed before the important developments of the 1990s. The previous studies have focused on a single type of regulation –fuel economy, emissions, or safety – and did not include consideration of the various classes of vehicles, including light trucks and SUVs. In addition, they did not span the complete period of 1975 to the present (2003). Also past studies did not have available for analysis an extensive data base of vehicle attributes and price characteristics like that compiled at UC Davis as part of the present study for the historical period of interest in which government regulations become a dominant consideration for the auto industry.

2. Changes in Regulations

2.1 Vehicle Emissions

Vehicle emissions have been regulated since the early 1960s starting with the control of crankcase emissions in 1961-63 and fuel evaporative and tailpipe emissions in 1970-71. The early emission standards were set primarily based on work done in California to reduce smog in the South Coast Air Basin. National vehicle emission standards resulted from the passage of the Clean Air Acts and amendments in 1963, 1965, 1967, and 1970. The emissions standards and how they have changed over the years are shown in Figure 1 (Reference 1). Up until 1975, it was possible to meet the standards by controlling engine spark timing and air-fuel ratio and using exhaust gas recirculation (EGR) and secondary air addition in the exhaust manifold. Unfortunately these changes in the engine operation resulted in a significant fuel economy penalty at a time when the country was very concerned about the availability and price of oil.

Figure 1 U.S. Tailpipe Emission Regulations



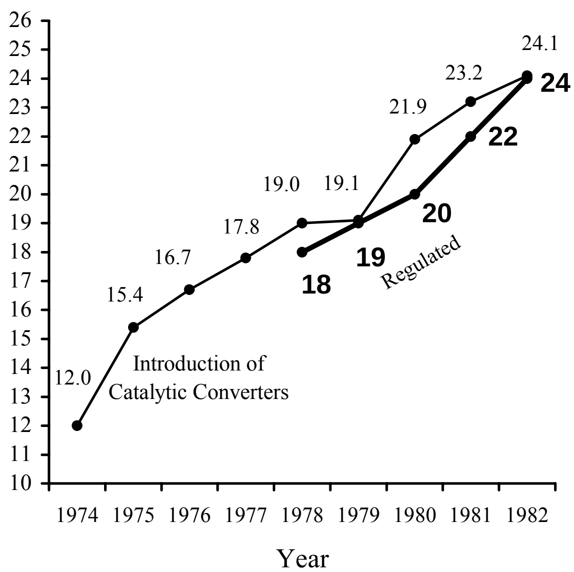
Source: Mondt, Reference 1.

The more stringent emission standards mandated by the Clean Act of 1970 were implemented in 1975. These new standards (1.5 gm/mi HC, 15 gm/mi CO, and 3.0 gm/mi NOx) were met using an oxidation catalytic converter. This new technology was the beginning of a long series of technology improvements that resulted in both large decreases in emissions and significant increases in fuel economy. This is illustrated in Figure 2 (Reference 1) for the period 1975-1982. During this period, vehicle exhaust emissions were reduced to .4 gm/mi HC, 3.4 gm/mi CO, and 1.0 gm/mi NOx and the average fuel economy of the new car fleet doubled from 12 to 24 mpg. The large reduction in NOx emissions was made possible through the introduction of three-way oxidation/reduction catalytic converters, electronic ignition, fuel injection, and engine computer control. Improvements in these technologies in the period 1990-present have resulted in further reductions in vehicle emissions to the current California ULEV and SULEV standards. These California emission and the EPA Tier 2 standards are summarized in Table 1. Several auto companies are marketing mid-size passenger cars in 2003 that meet the SULEV standards and have near –zero evaporative emissions. In California, these vehicles are termed PZEVs (partial zero-emission vehicles). Hence the new technology introduced in automobiles in less than 30 years has resulted in the reduction of HC and NOx emissions by more than 99%.

2.2 Fuel economy (CAFE)

In 1975, the Congress passed the Energy Policy and Conservation Act which established Corporate Average Fuel Economy Standards (CAFE) for passenger cars. The standards (Table 2) became effective in 1978 starting at 18 mpg increasing to 27.5 mpg in 1985. The rate of increase in mpg was highest in the period 1980-1984. Light truck CAFE standards were also established starting at 17.5 mpg in 1982 increasing to 20.7 mpg in 1996. These standards are currently applicable to light trucks, minivans, and sport utility vehicles. The light truck standard will increase by 1.5 mpg to 22.2 mpg in 2007.

Figure 2 Sales-weighted fuel economy history for GM cars



Source: Mondt, Reference 1.

The auto industry was successful in increasing fuel economy in the early years (1978-1985) when the standards were changing significantly from year to year. During that period, many vehicles (especially in the larger vehicle classes) were downsized with significant weight reductions. This redesign of the vehicles and the incorporation of engine improvements needed to meet the changes in the emission standards imposed in the same period resulted in large increases in fleet fuel economy. Since 1985, the fleet average fuel economy of passenger cars has changed very little remaining at about 28 mpg. Engines with variable valve actuation/timing and 4, 5, and 6 speed automatic transmissions with lockup in several of the gears have been introduced in more recent years. These technology improvements result in increased driveline efficiency and the potential for increased fuel economy, but the auto industry has utilized them to increase vehicle performance (decrease 0-60 mph acceleration times). Mid-size cars are now marketed (2003) with 4 cylinder (160 HP) engines and 4-speed automatic transmissions that have a composite fuel economy of 32 mpg (uncorrected), which is well above the CAFÉ standard of 27.5 mpg. These cars have a 0-60 mph acceleration time of 8.5 sec and meet the California SULEV emission standard (designated PZEVs).

Table 1 Federal and California Emission Standards

	Federal Standards (g/mi – fleet average)		
	ULEV		Tier 2(1)
	Cars	LDT2	LDV, MDV
HC	0.09	0.13	0.09
CO	4.2	5.5	4.2
NO_x	0.3	0.5	0.07
	California Standards (g/mi)		
	ULEV	SULEV	Tier 2 (Bin 5)
HC	0.04	0.01	.09
CO	1.7	1.0	4.2
NO_x	0.05	0.02	0.07
PM	0.01	0.01	0.01
	1993 → 2003 (g/mi – fleet average)		
	HC	0.4 → 0.06	
	CO	1.7 → 1.0	
	NO_x	0.2 → 0.05	

(1) 120,000 mile durability, phased in by 2007 for all light-duty vehicles, phased in by 2009 for medium-duty vehicles (8,500 – 10,000 lbs.)

The improved engine and transmission technologies have also been utilized in the light truck, minivan, SUV classes of vehicles. This has resulted in composite fuel economies in 2003 of 22.2 mpg (uncorrected) for several light trucks, 24.6 mpg for several minivans, and 24.2 mpg for several mid-size SUVs. All these vehicles use 3 liter, V6 engines (220 HP), 4-speed automatic transmissions, and have 0-60mph acceleration times of about 8.5 sec. The CAFÉ fuel economy standard for these vehicles 20.7 mpg. Hence vehicles are presently being marketed that have fuel economies above the standard for 2007.

Table 2 Federal Fuel Economy Standards (CAFE)

Model Year	Cars	Light Trucks	Model Year	Cars	Light Trucks
1978	18.0	-	**1990**	27.5	20.0
1979	19.0	-	**1991**	27.5	20.2
1980	20.0	-	**1992**	27.5	20.2
1981	22.0	-	**1993**	27.5	20.4
1982	24.0	17.5	**1994**	27.5	20.5
1983	26.0	19.0	**1995**	27.5	20.6
1984	27.0	20.0	**1996**	27.5	20.7
1985	27.5	20.5	**1997**	27.5	20.7
1986	26.0	20.5	**1998**	27.5	20.7
1987	26.0	20.5	**1999**	27.5	20.7
1988	26.0	20.5	**2000**	27.5	20.7
1989	26.5	20.5	**> 2000**	27.5?	22.2 (phase-in by 2007)

Source: Reference 8, Tables 7.18 and 7.19.

3. Industry/consumer data base

In order to assess the response of the auto industry and consumers to the changes in emissions and fuel economy regulations from 1975-2003, it is necessary to study closely the changes in the characteristics of the vehicles marketed during that period and the prices and sales of those vehicles. Fortunately there are data available on most aspects of the automobile industry and the products they market from many sources including industry publications, consumer car magazines and buyers guides, and government agencies. A summary of data sources used in this study is given in Table 3.

Data on the production and sales of vehicles and components for each year are given in industry publications such as the Automotive News and Ward's Automotive Yearbooks. Data on vehicle and accessory prices are given in consumer magazines and buyer's guides as well as the industry publications. The data in these sources are given for the various models for each of the auto manufacturers. Fuel economy data (adjusted for real world driving) for the various vehicle models are given in the Fuel Economy Guide compiled annually by EPA and DOE. Dynamometer test data for emissions and fuel economy for many vehicle models are given in an electronic data base prepared by EPA (Reference 2). Detailed characteristics of many popular vehicle models are available in special issues of Consumers Report and car magazines such as Car and Driver and Road and Track. These publications independently test the various vehicles for acceleration, handling, and fuel economy and publish the results. Key sources of macro-economic and vehicle related price data are the Bureau of Economic Analysis in the United States Department of Commerce and the Bureau of Labor Statistics (BLS) in the Department of Labor. The BLS prepares annual summaries of the average price of automobiles with breakdowns of the contribution of various component groups to price changes.

A computer data base has been prepared using data obtained from the various sources given in Table 3. The vehicle data for each year (1975-2003) are organized by vehicle class and model using the model names given by the various manufacturers. Sales data are given by vehicle class, manufacturer, and model group. Sales of different models within a model group were difficult to find. Some such data are available in Reference 3. Macro-economic data from the Commerce and Labor Departments are included for each year of interest in the study. The types of data included in the UC Davis Vehicle Data base are summarized in Table 4. The database includes information on between 89 (1975) and 186 (2002) models for each year and in total contains about 9500 complete data entries. Experience with the database has shown it is easily and quickly accessed and analyzed using SPSS, ACCESS, and EXCEL. Data from the UC Davis Data base are given in Appendix II for selected vehicles and calculated average values for vehicle characteristics in the various classes are given in Appendix III.

Table 3 Data Sources used in the report and the assembly of the UC Davis Vehicle Database

Source	Data Description	
U.S. Environmental Protection Agency, Fuel Economy Guide Database, 1978-2002, See: http://www.epa.gov/otaq/fedata.htm.	See Table 2.	Database
U.S. Environmental Protection Agency, Test Car List Database, 1984-2002, See: http://www.epa.gov/otaq/tcldata.htm.	See Table 2.	
Ward's Communications (Various Years) *Ward's Automotive Yearbook*. Annual. New York: Primedia, Inc., 1970-2002.	See Table 2.	
Consumer Reports (Various Years) *Annual Auto Issue*. Mount Vernon, NY: Consumers Union. 1975-2003.	See Table 2.	
U.S. Department of Commerce, Bureau of Economic Analysis, Office of Automotive Affairs. See: http://www.ita.doc.gov/td/auto/qfact.html.	Average transaction price, motor vehicle output and sales, motor vehicle industry corporate profits, employment, and personal income.	Tables & Figures
U.S. Department of Labor, Bureau of Labor Statistics (2003) Consumer Price Index—All Urban Consumers, http://www.bls.gov/cpihome.htm.	Consumer Price Indices	
U.S. Department of Labor, Bureau of Labor Statistics (2003) Producer Price Index, http://www.bls.gov/ppihome.htm.	Producer Price Indices	
Automotive News (Various Years) *Market Data Book*. Detroit: Crain Communications, 1980-2003.	Confirmation and addition to Ward's data	
U.S. Census Bureau, Historical Income Tables - Households, See: http://www.census.gov/hhes/income/histinc/h05.html	Household Income	
Davis, Stacy G. (2002) *Transportation Energy Data Book: Edition 22*. Oak Ridge National Laboratory, U.S. Department of Energy. See: http://www-cta.ornl.gov/cta/data/Index.html	Comprehensive collection of relevant transportation data.	
Hellman, Karl H. and Heavenrich, Robert M. (2003) *Light-Duty Automotive and Fuel Economy Trends: 1975 Through 2003*. U.S. Environmental Protection Agency, Office of Mobile Sources, April 2003. (EPA420-R-03-006) See: http://www.epa.gov/otaq/cert/mpg/fetrends/r03006.pdf	Latest annual report tracking fuel economy and vehicle attribute trends.	

Table 4 Description and source of Data in the UC Davis Vehicle Database

Column Header	Description	EPA	Wards	CR
Year	Model Year	X		
Class	EPA Vehicle Class (available only for 1978-2003)	X		
Manufacturer	Manufacturer name (note that some manufacturers have been omitted)	X		
carline name	Model name (note that vehicle series are not distinguished)	X		
wheelbase	Length of wheelbase in inches		X	
curb weight	Curb weight in pounds		X	
gross vehicle weight	Gross vehicle weight (curb weight + maximum rated load + passenger weight) in pounds for light trucks only		X	
maximum rated load	Maximum rated load in pounds			X
horsepower	Net horsepower		X	
traction	Traction Control: Blank=none; 1=optional; 2=standard			X
abs	Anti-lock Brakes: Blank=none; 1=optional; 2=standard		X	
hp-ca	Net horsepower for California vehicles (only early imports)		X	
msrp	Manufacturer suggested retail price in nominal dollars		X	
airbag	Airbags: Blank=none; 1=driver; 2= dual; 3=side; 4=rear/side; 5=ceiling		X	
Towing Capability (lb.)	Towing capability in pounds (mostly light trucks)			X
0-30	Acceleration 0-30mph in seconds			X
0-60	Acceleration 0-60mph in seconds			X
45-65	Passing acceleration in seconds			X
195-mile trip fuel economy	Consumer Reports road trip test fuel economy in mpg			X
Fuel Econ City Driving	Consumer Reports city test fuel economy in mpg			X
Fuel Econ Express-wayDriving	Consumer Reports highway test fuel economy in mpg			X
cyl	Number of cylinders	X		
DISP CI	Engine displacement in cubic inches	X		
fuel system	Number of carburetor barrels or type of fuel injection: MPFI=multiport fuel injection; SFI=sequential fuel injection; IDI=indirect fuel injection; TBI=throttle-body injection; EFI=electronic fuel injection; VV=variable venture	X		
displ (liters)	Engine displacement in liters	X		
optional disp	Optional displacement in liters	X		
trans	Transmission type (A=automatic; M=manual; L=lockup)	X		
overdrive	OD=overdrive, EOD=electronic overdrive; AEOD=automatic overdrive	X		
catalyst	Y=catalyst; N=no catalyst	X		
drv	Drive axle type: FWD, RWD, 4WD	X		
cty	Adjusted city fuel economy	X		
hwy	Adjusted highway fuel economy	X		
cmb	Adjusted combined fuel economy	X		
ucty	Unadjusted city fuel economy	X		
uhwy	Unadjusted highway fuel economy	X		
ucmb	Unadjusted combined fuel economy	X		
fl	Fuel type: L=leaded gasoline; U=unleaded gasoline; D=diesel	X		
G	Gas guzzler vehicle	X		
eng dscr 1	Engine description 1	X		
eng dscr 2	Engine description 2	X		
eng dscr 3	Engine description 3	X		
trans dscr	Transmission description	X		
cls	Valves per cylinder (2000 and later)	X		

4. Industry response

In this section of the report, the industry response is described and analyzed in terms of historical trends in changes in technology, weight/size and performance characteristics, and prices for vehicles marketed in the various vehicle classes. These changes can be overlayed with the emissions and fuel economy regulations and economic activity in the years of interest (1975-2003). When possible, special consideration will be given to changes directly related to California emission standards that are in some years significantly different than those of most other states.

4.1 Historical review of technology changes

This review of technology changes in autos and other light duty vehicles is concerned with the period 1975 to the present. Development of emission control technology started in the 1960s (Reference 1) with the advent of the early emission standards in California and the Clean Air Acts of 1963 and 1965, but the technology developments of interest in this study are those that have been the major contributors to the achievement of the present ultra-clean vehicles (ULEV and SULEV) and the large improvements in fuel economy that followed the imposition of the CAFE standards in 1978. It is those technology changes along with the battery and electric driveline developments from the ZEV Mandate (Reference 4), which will form the foundation for future vehicle designs that can result in significant reductions in CO_2 emissions from those vehicles. It is of interest to note that many of the technologies developed to meet the stringent emission standards have played a large role in improving fuel economy and the performance of the vehicles presently being marketed.

In this section, technologies are identified and the time periods in which they were introduced cited in relationship to the changing emissions and fuel economy regulations. For each of the technology changes, their consequences relative to improvements in vehicle emissions and fuel economy and the years of large scale introduction are presented in Appendix I. Time-lines for the introduction of the technologies are shown graphically in Figure 3 in a form that can be compared easily with a similar presentation of the time-lines for the changes in regulations. The technology time-lines will be used in later sections of the report to compare with time-based changes in vehicle price and sales.

As shown in Figure 3, the periods of most rapid technology change were the second half of the 1970s and the first half of the 1980s. The first changes in the 1970s were a downsizing of the cars both in terms of size (wheel base) and weight in order to increase fuel economy. This downsizing involved primarily the larger cars (mid- and full-size). Weight reductions of 1000-1200 lbs were achieved in the full-size cars. In addition, many of the car designs were changed to front-wheel drive as part of the downsizing. During this period, closer attention was given to aerodynamics with the resultant decrease of 10-20% in the drag coefficient of the vehicles. Further reductions in road load were achieved by the use of improved radial tires with lower rolling resistance. Accessory loads were reduced where possible. For example, electric radiator cooling fans replaced the fans driven off the engine. In general, maximum engine power was reduced with the utilization of 4 –cylinder engines and V-6s in place of V-8s. Vehicle acceleration times remained relatively unchanged during this period. Most of the larger

Figure 3 Timeline of Technology Change with Fuel Economy & Emissions Requirements Overlay

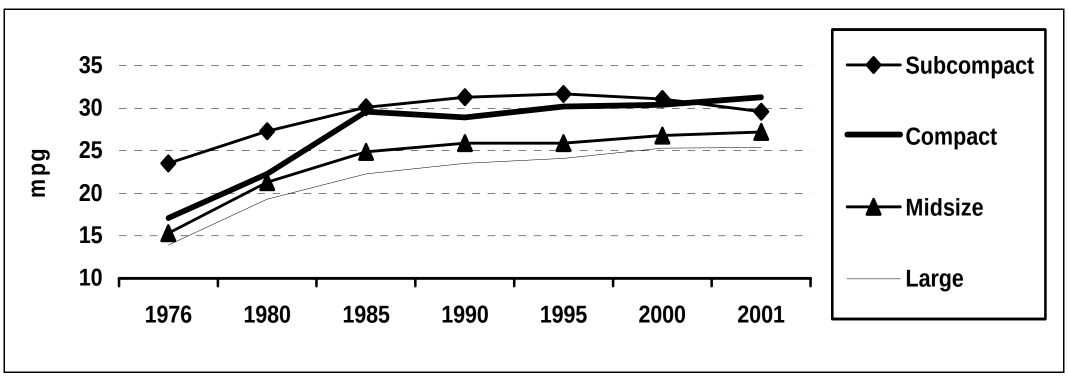
Year	Emissions		Fuel Economy		Technology	
1975		←——			——→	Radial Tires, Reduced C_D
1976		1.5g/mi HC			Oxidation Catalyst	←——
1977		15g/mi CO			Front-wheel Drive	Electronic Engine Control
1978		3.1g/miNO_x	18→		——→	←——
1979				←19	Three-Way Catalysts	←—— Weight Reduction
1980			20→		——→	←——
1981	——→			←22	4-Speed Automatic Trans-	Electronic ignition and
1982	.41g/mi HC		24→		mission with Lockup	SP fuel injection
1983	3.4g/mi CO			←26		V-6 Engines
1984	1.0g/miNO_x		27→		——→	
1985				←27.5	Computer control of	
1986					engines; MP fuel injection	
1987						
1988						←——
1989						4-Valve per cylinder
1990						engines
1991			27.5→			
1992					Batteries and electric drives	
1993						
1994						
1995						←——
1996						Variable Valve Timing
1997						
1998	NLEV				5 & 6-speed Auto Trans-	
1999	.09g/mi HC 4.2g/mi CO				mission with Lockup	
2000	0.3g/miNO_x				——→	←——
2001	——→					Ultra Clean Emissions
2002		Tier 2 (2007) .07g/mi HC			Hybrid-electric powertrains	
2003		4.2g/mi CO .09g/miNO_x				
2004		←——				
2005						

cars used 3-speed automatic transmissions, but close attention was given to matching the gearing and shift strategy to the engine to improve fuel economy. As shown in Figure 4 (Reference 5), these technology changes resulted in marked improvements in the CAFE fuel economy (composite of FUDS and Highway) of all classes of passenger cars. The increase was 40-50% in each of the classes by 1980. In addition to the technology changes to improve fuel economy, there were changes to reduce emissions. The most significant of these changes was the use of a two-way oxidation catalytic converter in the exhaust system of the engine which permitted the optimization of the spark timing and EGR near that for the best engine efficiency at each torque and speed. As result of the use of the oxidation catalyst, the vehicle emissions were reduced from 3 to 1.5 gm/mi

HC, 28 to 15 gm/mi CO, and 3 to 2 gm/mi NOx and at the same time the fuel economy was improved as previously cited.

A second period of rapid technology change was initiated in early 1980s with the change in the emission standard to .4 gm/mi HC, 3.4 gm/mi CO, and 1 gm/mi NOx. These reductions in the emission standards lead to the use of a three-way, oxidation/reduction catalytic converter in place of the two-way, oxidation catalytic converter. For the three-way catalyst to function at high conversion efficiency for all three pollutants, the engine air-fuel ratio must be maintained very near (within about 1%) to stoichiometric. To operate the engine in this manner required several new engine technologies- namely, fuel injection, electronic ignition, an O2 sensor, and computer control of engine operation. By 1985, nearly all new passenger cars were equipped with these new technologies, which in addition to greatly reducing emissions, also resulted in continued improvements in fuel economy. Note from Figure 4 that the average CAFE fuel economy of small cars increased to 30 mpg, that of mid-size cars to 25 mpg, and that of large cars to 22 mpg. During this period, the 0-60 mph acceleration times decreased by about 1.5 seconds. This was the beginning of a trend in decreasing acceleration times that would continue up to the present time.

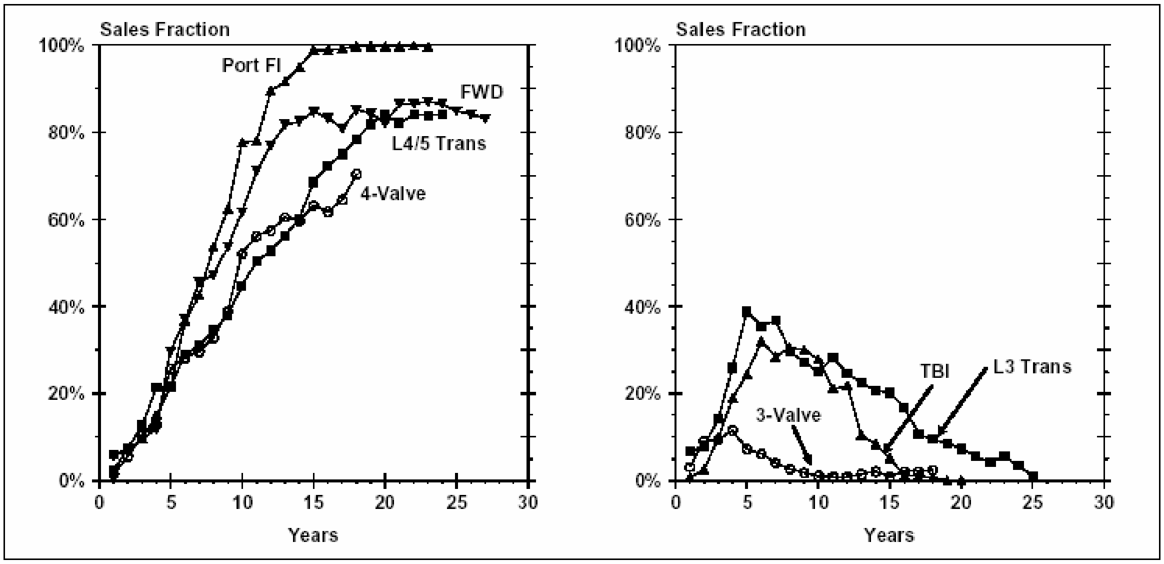
Figure 4 History of Passenger Car Fuel Economy (CAFE)



Source: Reference 8, Table 7.7.

In the period 1985-1995, the emissions and fuel economy standards remained essentially unchanged except for the beginning of the tightening of emission standards in California as part of the LEVI program. During this period, the auto industry refined the advanced engine control technologies introduced in the first part of the 1980s. In addition, there was considerable engine development resulting in the introduction of 4-valve per cylinder engines and increases in the compression ratio from 8.5 to 9.5 or higher. This resulted in higher engine efficiency and large improvements in engine specific power (HP/liter displacement). In addition, 4-speed automatic transmissions with lockup in 4th gear were developed and utilized in the larger cars. The average CAFÉ fuel economy for small and mid-size cars remained essentially unchanged during this period, but the average fuel economy of the large cars increased to 25 mpg. The acceleration times decreased continuously reaching 10-11 seconds from 13 seconds ten years earlier. Hence the improvements in engine and transmission technologies developed from 1985-1995 were utilized primarily to improve vehicle performance rather than fuel economy. Nevertheless, these technology improvements were significant and set the stage for even more impressive developments in the future. Note from Figure 5 that even for new technologies that have clear advantages, it takes 10-15 years before the old technology is almost completely replaced by the new technology.

Figure 5 Car Technology Penetration Years after Significant Use



Source: Reference 29, p.27, Figures 26 & 27.

Consider next the period from 1995 to the present (2003). During this period, the refinement of the engine and transmission technologies continued. In the case of engines, the multi-point fuel injection systems were developed, compression ratio was further increased with some engines having a ratio of 10 or greater, and variable valve actuation/timing was introduced by several auto companies. These new technologies resulted in further improvements in engine efficiency and exhaust emissions. By 2003, Honda, Toyota, Ford, Volvo, and several other manufacturers were marketing cars that meet the California SULEV standard (see Table 1). Most of the auto companies are marketing some cars that meet the California ULEV standard. Transmission development continued with the introduction of 5 –speed automatic transmissions with lockup in several gears. The combination of engine and transmission improvements has lead to significant improvements in fuel economy. For example, the 2003 Honda Accord has a composite CAFÉ fuel economy of 32.3 mpg along with its SULEV emissions. This fuel economy is 17% greater than the 27.5 mpg CAFÉ standard. The Accord has a 4 cylinder, 160 HP engine and a 5-speed automatic transmission resulting in a 0-60 mph acceleration time of 9 seconds. Many mid- and full-size cars have V-6 engines. These cars have lower fuel economy and better acceleration times than the 4-cylinder versions and presently meet only the ULEV emission standard. It can be expected that the advanced engine technologies cited above will be further improved and be used in most of the cars of all classes in the near future (within five years).

4.2 Historical review of changes in vehicle characteristics

There have been major changes in the characteristics of the vehicles marketed by the auto industry worldwide since 1975. These changes have accelerated in the last 10 years. Table 5 shows the changes in the sales fractions of light-duty vehicles in the various classes. In 1976, over 80% of vehicles sold were passenger cars with 56% of those cars being small cars (subcompact and compact). In 2000, less than 52% of the vehicles sold were passenger cars and only 47% were small cars. In recent years, the vehicle class with the most rapid sales increase has been sport utility vehicles (SUVs). In 2000, SUVs accounted for 20% of sales with mid-size SUVs being the largest fraction at 12.5%. Sales of vans and pickup trucks have increased from 1975 to 2000, but not as much as SUVs. The sales of pickup trucks increased from13% to nearly 17% in that period while sales of vans increased from 4.5% to 9.5%. In total, sales of trucks, vans, and SUVs accounted for 48% of sales in 2000. In 2002, the sales fraction was 50.6% and it is projected to increase to 52.8% by 2005 (Reference 6). Note in Table 5 that the total sales of light duty vehicles (cars, minivans, SUVs, and light trucks) have increased from about 14 million in 1976-8, to 15 million in the mid-1980s, and to 17 million in 2000.

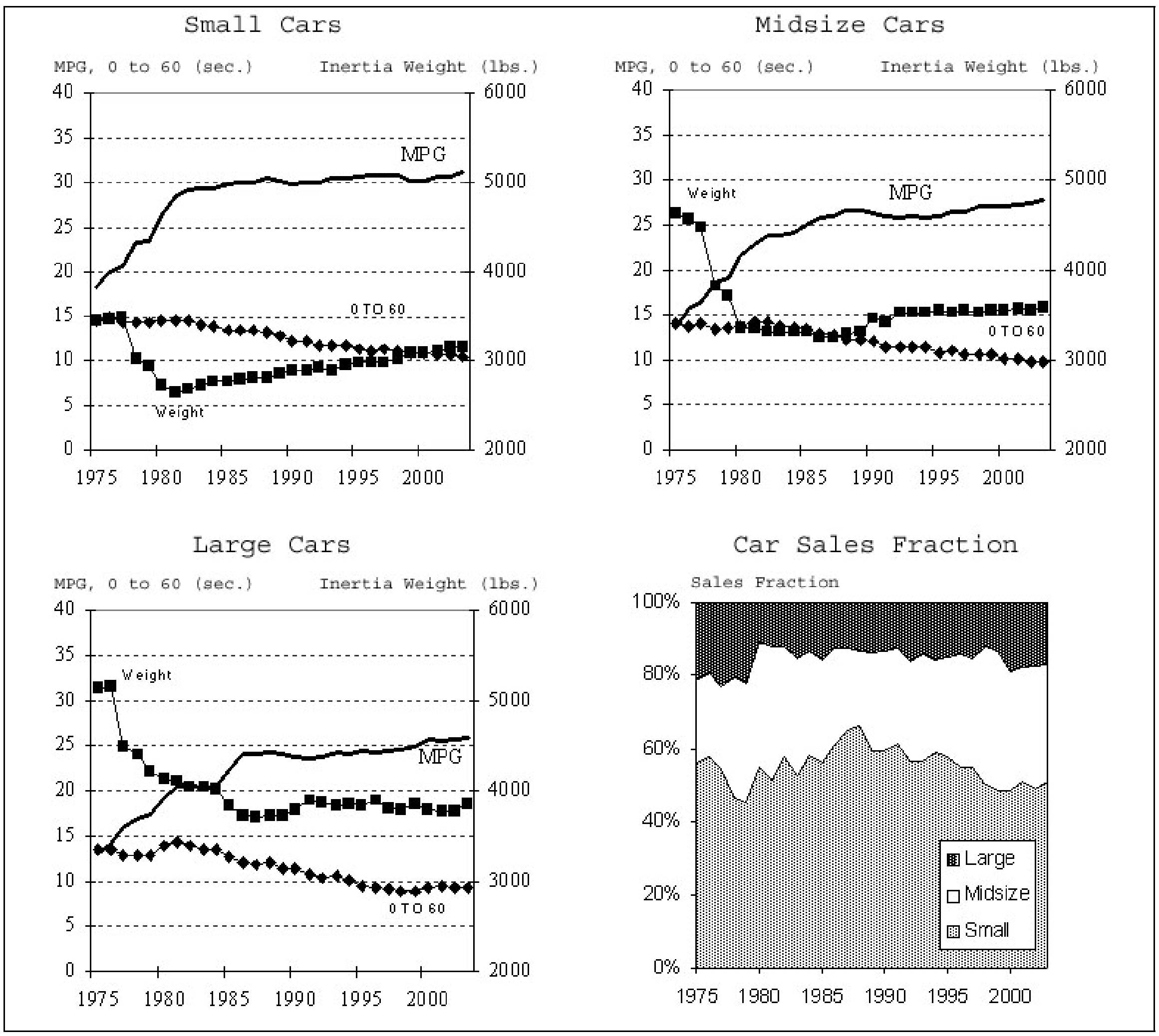
Table 5 Historical Vehicle Sales - Total and by class

Year	Car Sales (millions)			Car Sales (%)			Vans, SUVs, light.trks	Total Sales (millions)
	Domestic	Import	Total	small	midsize	large		
1975	7,053	1,571	8,624	55.4%	23.3%	21.3%	20.9%	10,905
1976	8,611	1,499	10,110	55.4%	25.2%	19.4%	22.6%	13,066
1977	9,109	2,074	11,183	51.9%	24.5%	23.5%	23.5%	14,613
1978	9,312	2,002	11,314	44.7%	34.4%	21.0%	25.2%	15,122
1979	8,341	2,332	10,673	43.7%	34.2%	22.1%	23.7%	13,984
1980	6,581	2,398	8,979	54.4%	34.4%	11.3%	21.4%	11,419
1981	6,209	2,327	8,536	51.5%	36.4%	12.2%	20.4%	10,725
1982	5,759	2,223	7,982	56.5%	31.0%	12.5%	23.6%	10,452
1983	6,795	2,387	9,182	53.1%	31.8%	15.1%	24.5%	12,166
1984	7,952	2,439	10,391	57.4%	29.4%	13.2%	27.1%	14,254
1985	8,205	2,838	11,043	55.7%	28.9%	15.4%	28.8%	15,501
1986	8,215	3,238	11,453	59.5%	27.9%	12.6%	28.6%	16,047
1987	7,081	3,197	10,278	63.5%	24.3%	12.2%	31.0%	14,888
1988	7,526	3,099	10,626	64.8%	22.3%	12.8%	31.1%	15,426
1989	7,073	2,825	9,898	58.3%	28.2%	13.5%	31.8%	14,508
1990	6,897	2,404	9,301	58.6%	28.7%	12.8%	32.8%	13,849
1991	6,137	2,038	8,175	61.5%	26.2%	12.3%	33.5%	12,298
1992	6,277	1,937	8,213	56.5%	27.8%	15.6%	36.0%	12,842
1993	6,742	1,776	8,518	57.2%	29.5%	13.3%	38.6%	13,869
1994	7,255	1,735	8,990	58.5%	26.1%	15.4%	40.2%	15,023
1995	7,129	1,506	8,635	57.3%	28.6%	14.0%	41.2%	14,688
1996	7,255	1,271	8,526	54.3%	32.0%	13.6%	43.3%	15,045
1997	6,917	1,355	8,272	55.1%	30.6%	14.3%	46.6%	15,069
1998	6,762	1,380	8,142	49.4%	39.1%	11.4%	47.3%	15,441
1999	6,979	1,719	8,698	47.4%	40.0%	12.5%	48.1%	16,771
2000	6,831	2,016	8,847	47.5%	34.3%	18.2%	48.7%	17,234
2001	6,325	2,098	8,423	50.9%	32.3%	16.8%	50.5%	17,021

Source: Reference 8, Table 7.6; Reference 5, Table 2.

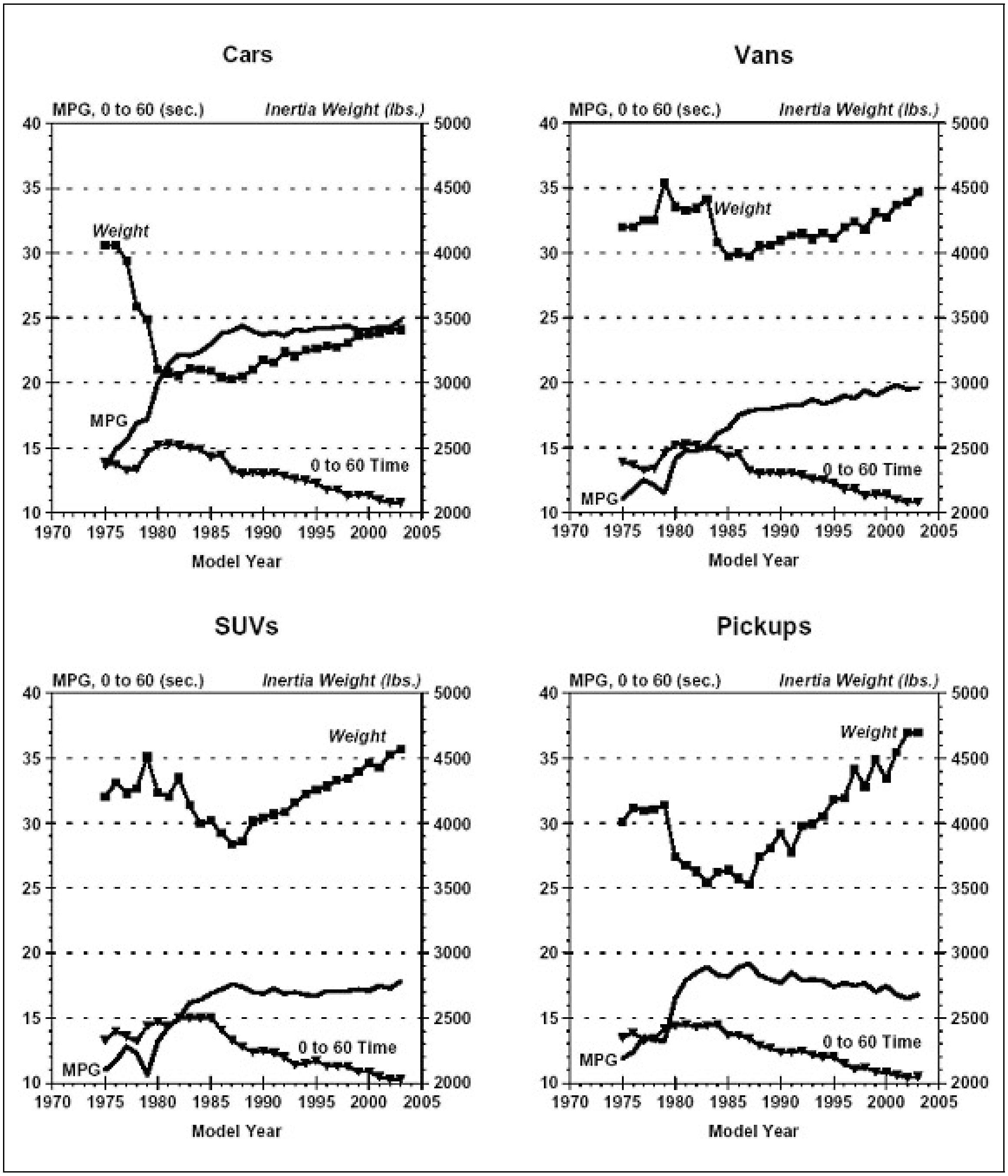
The changes in the characteristics of passenger cars since 1975 are shown in detail in Figure 6. The new technologies were introduced first in these vehicles to meet the emissions and fuel economy standards. To some extent the new technologies have also been used in the larger light duty vehicles, but not completely as the emissions and fuel economy requirements for the vans, SUVs, and light trucks were not as demanding as for passenger cars. The changes of vehicle characteristics for the larger light-duty classes are given in Figures 7 (Reference 5). The data shown in Figure 6 and 7 are for the mid-size models of each of the vehicle classes. As in the case of passenger cars, there has been a significant improvements in both the acceleration performance and fuel economy of vans, SUVs, and light-duty trucks since 1975. The 0-60 mph acceleration times have decreased from 15 to 10sec. This resulted from a small weight reduction and an increase in engine HP to 200-240 from 120-150 HP. As indicated in Figures 7, the fuel economy increased by 50-75% with most of the increase occurring before 1990.

Figure 6 Fuel Economy, Performance, Weight & Sales Fraction Trends for Cars (1975-2003)



Source: Reference 29, Figures constructed from datasets.

Figure 7 Fuel Economy, Performance and Weight Trends for Vehicles (1970-2003)



Source: Reference 29, p.36, Figures 33 – 36.

After 1990, except for the vans, the fuel economy of the larger light duty vehicles either was flat or showed a slight decrease. As in the case of passenger cars, the emission standards for the vans, SUVs, and pickup trucks were greatly reduced for all three pollutants – HC, CO, and NOx.. The small and mid-size models fall into the LDT2 category with GVWR between 3751 and 5750 lbs. The emission standards for these vehicles are .13 gm/mi HC, 5.5 gm/mi CO, and .3 gm/mi NOx (100,000 miles durability). The emission standards in 1975 were 2, 20, and 3.1 gm/mi for HC, CO, and NOx, respectively. Hence even though, the large light-duty vehicles have significantly higher emissions than passenger cars their emissions have been greatly reduced since 1975 and their fuel economy has been significantly increased. Further improvements in both emissions and fuel economy will result when all the new technologies presently incorporated into the most advanced passenger cars are applied to the larger vehicles.

4.3 Historical Review of vehicle price changes

The price history and characteristics of a number of light-duty vehicles are given in Appendix II for 1975-2003. The price history for a selected number of those vehicles is shown in Figures 8-11. The prices shown are the MSRP for the baseline models for each year. The car models selected for plotting were ones that have been offered for sale for the complete period of interest or for a substantial fraction of it. Most of models selected remained in the same class for the entire period. The four figures include models from the compact, midsize and large car segments, as well as one for SUVs and minivans. Prices are given in 2002$ using the general consumer price index (Figure 12). Note that there is a steady increase in the price of the cars even in the adjusted real dollars. This is not surprising as the value of the vehicles to the car owner and society has continuously increased with greatly reduced emissions and improved fuel economy and the addition of many amenities, such as enhanced interiors, climate control, CD players, and cruise control, etc. In addition, over this period numerous safety regulations have been instituted, including driver side airbags. The cost of the air bags alone is likely to be at least several hundred dollars (Reference 7).

Figure 8 MSRP Trends in $2002 for a Selection of Compact Cars

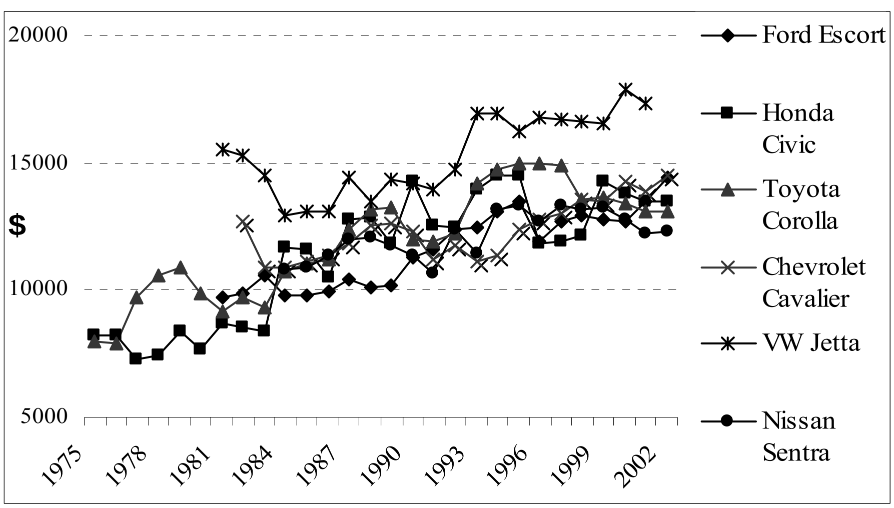


Figure 9 MSRP Trends in $2002 for a Selection of Midsize Cars

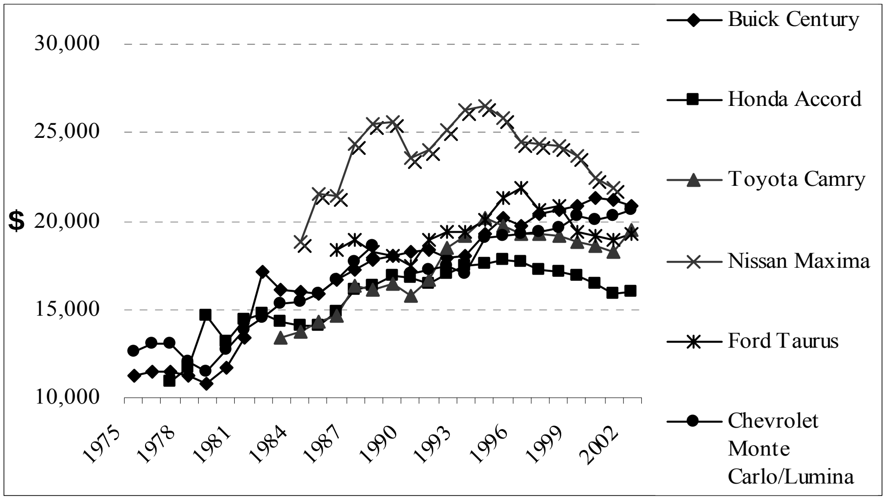


Figure 10 MSRP Trends in 2002$ for a Selection of Large Cars

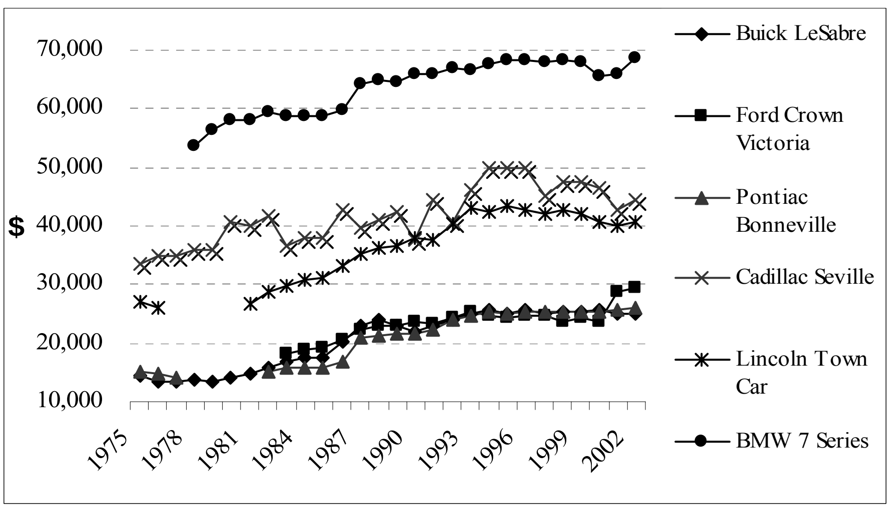
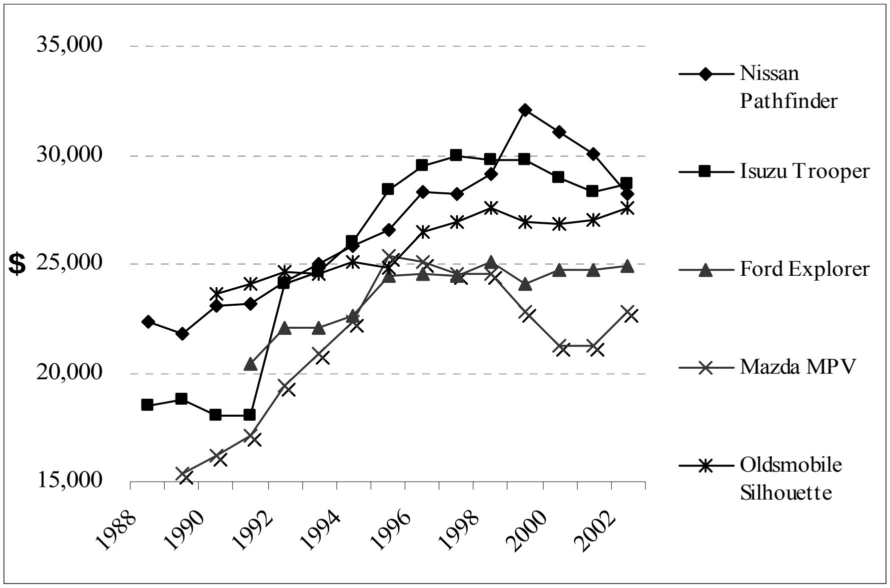


Figure 11 MSRP Trends in 2002$ for a Selection of SUVs and Minivans



The shape of the price curves vs. time (years) varies between the various vehicles with the periods of maximum rate of price increase occurring at different times. One would expect that the maximum price increases would occur for years in which new technology is added to the vehicles in response to changes in regulations whether the changes are in emission, fuel economy, or safety. A close look at the price data in Appendix 2 shows that in general this is the case if one considers two relatively short periods of time in which the technology changes were concentrated. These periods are 1977-1982 and 1990-94. Price increases occur nearly every year, but for the periods cited the price increases for many of the models are significant greater than the average for at least one year in the period. The new technology is integrated into the various models in different years as the models change. Also in some cases it appears that for marketing reasons the total cost of the new technology is included in price increases over several years rather than all in one year. In current dollars, the price increase from year to year can be as much as $1000-$2000 for the smaller cars and up to $3000-$4000 for the larger more expensive cars. Note that after 1995 the price increases are smaller than in the earlier years when regulations were changing significantly. Note also in Figure 12 that the consumer price index for new vehicles leveled off after 1995. The average list price increases in 2001$ for passenger cars are shown in Table 6 and Figure 13. The price increases are the largest in 1977-1982 and 1990-92 when there were large changes in the emissions and fuel economy standards.

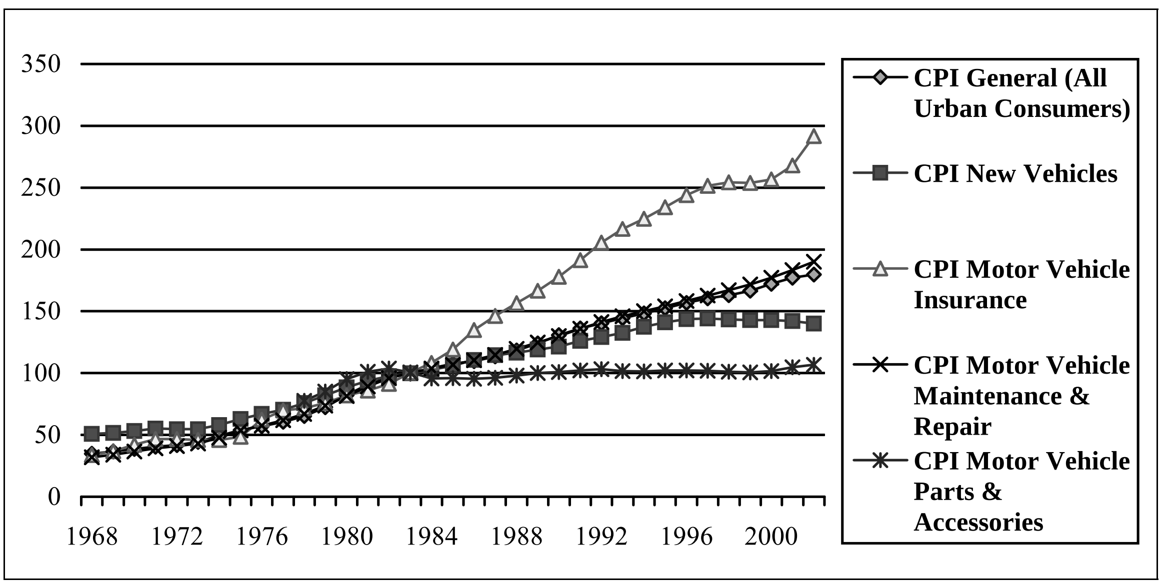
Part of the vehicle price increase each year is due to improvements (higher quality and value of the vehicle to the buyer) in the vehicle and some is due to higher general costs to the manufacturer. These two costs on an average basis for all vehicles sold in a given year have been tracked by the Bureau of Labor Statistics (BLS). The data are included in Table 6 for the period 1970-2001. Note in Table 6 that the value/quality price increases are higher than average in the two periods cited previously both in terms of current dollars and 2000$. Most of the quality/value price increase is likely due to the introduction of new technology in the vehicles- both in the powertrain and for safety. The average quality price increases during the peak change years are in excess of $1000 in 2000$.

The question is often asked as to how the value of a new car increased over the years relative to the value of other products. One way of answering this question is to compare the general consumer price index (cpi) and the new vehicle consumer price index (vpi). It is seen in Figure 12 and in the table below that the cpi increases more rapidly than the vpi especially in the years after 1990. For the period 1975-2001, the ratio of the change in the two indices is 1.46 with the cpi showing the larger increase. This indicates that although the price of cars has increased significantly in real dollars over the period of interest, car buyers have gotten a better value for their money than purchasers of most other products.

Year	cpi	vpi	cpi/cpi1975	vpi/vpi1975	cp ratio
1975	53.8	62.9	1.0	1.0	1.0
1980	82.4	88.4	1.53	1.41	1.085
1985	107.6	106.1	2.0	1.69	1.183
1990	130.7	121.4	2.43	1.91	1.272
1995	152.4	139.0	2.83	2.21	1.28
1998	163.0	143.4	3.03	2.28	1.33
2000	172.2	142.8	3.2	2.27	1.41
2001	177.1	142.1	3.29	2.26	1.46

Source: World Almanac 2003, base year 1983=100

Figure 12 Trends in the Consumer Price Index for All Urban Consumers (1968-2002)



Source: U.S. Department of Labor, Reference 27.

The question is also often raised as to how much of the average price increase in constant dollars of vehicles over the period 1975-2001 has been due to government regulations and how much to improvements in the quality of the vehicles. This has been estimated in the following manner. In current dollars, the sales-weighted average price of vehicles sold in 1975 was \$4345 and in 2001 it was \$20896. Applying the vpi index to the 1975 price, the price of the car of the same quality as 1975 would be \$9820 in 2001\$. Hence the price difference between the 1975 and 2001 quality cars would be \$11076. It has been estimated in Ward's Automotive Yearbook (2002) that the price of regulations in 1975 was \$586 resulting in a cost of \$1324 in 2001\$. Hence without government regulations the cost of the 1975 vehicle in 2001 would have been \$8496 and the price difference with the 2001 models would have been \$12400. The estimated total price of regulations in 2001 has been estimated by Ward's to be \$4018. Hence the price of the 1975 vehicle with 2001 regulations would have been \$12514 resulting in a price difference of \$8382 due to quality improvements between 1975 and 2001. Hence the fraction of the price increase in 2001 due to quality improvements is **67.6%** and due to government regulation is **32.4%.**

Next consider what the price of the average vehicle sold would have been if the prices of vehicles had increased between 1975-2001 as fast as the general commodity index cpi. Without government regulations, the price of the 1975 vehicle in 2001 would have been \$12368 (3.29 x 3759). Adding the same \$12400 price differential determined previously, the price of a 2001 vehicle would be \$24748. Hence the actual price in 2001 was 18.5% or \$3872 less than it would have been had the auto industry price increases followed the general consumer price index. The average price of vehicles sold in constant dollars have increased by 46% between 1975-2001 rather than by 73% that would have been the case if the prices of the cars had increased the same as general sales items.

4.4 Vehicle prices in California

Questions have been asked as to how the prices of vehicles in California might differ from those in most other states because of the more stringent emission standards in California. The Federal and California standards began to be significantly different in 1993 with the implementation of the LEVI standards in California, which reduce the fleet average HC standard from .4 to .04 gm/mi and the NOx standard from .4 to .05 gm/mi by 2004. The lower limits of the California standards are ULEV and SULEV (see Table 1). The Federal emission standards, termed NLEV (National Low Emission Vehicle) or sometimes referred to as the 50-state standard, are .09 gm/mi HC, 4.2 gm/mi CO, and .3 gm/mi NOx. It is not surprising that the auto companies are certifying various models of their passenger cars to different standards ranging from NLEV to SULEV. The certification data given in the EPA emissions data base (Reference 2) indicates that for 2002 (the most recent data available) nearly all the cars are certified to HC less than .09 gm/mi and in some cases less than .05 gm/mi; the NOx certification values are in most cases less than .1 gm/mi and often less than .05 gm/mi; the CO certification values are nearly always less than 1 gm/mi. Even some minivans are being certified at very low values. For example, the Honda Odyssey with the 240HP V6 engine was certified at .057 gm/mi HC, .56 gm/mi CO, and .03 gm/mi NOx.

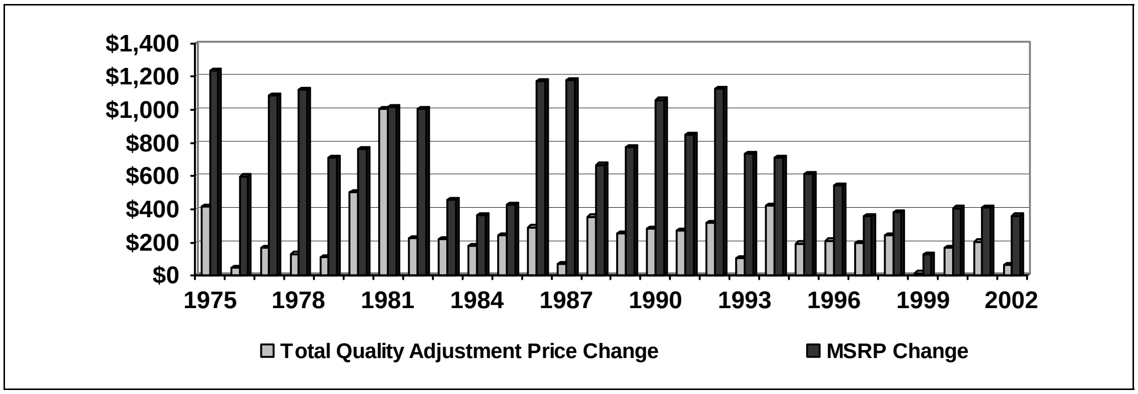
Discussions with technical contacts at Honda and Toyota indicated that those companies do not certify different models for California and the states with less stringent emission standards. In addition, when ULEV and SULEV models are available, they are sold in all states and there is not a price premium charged anywhere. For example, the prices charged for the complete Honda line (Civic to Odyssey) is the same for all models regardless of where they are sold in the United States. This is likely the result of the Federal and California emission standards being set based on a fleet average. The fleet average standards for both HC and NOx are becoming more stringent, but there is allowance for the inclusion of vehicles with different levels of emissions. Even when the Tier 2 Federal standards are completely phased in by 2007 for light-duty vehicles, including most minivans and SUVs, and by 2009 for medium-duty vehicles (8500-10000 lbs GVWR), the California standards will be more stringent for all these vehicles. However, based on present emission certification and pricing practices of the auto industry, it can be expected that the prices of the vehicles will be the same in California and the other states.

Table 6 Retail Price Changes and Average Change in Transaction Price (1975-2002)

Year	Average Retail Equivalent Price of All Motor Vehicle Quality Changes for New Cars(1)		Average Change in MSRP for New Cars from Previous Year(1)		Average Change in Transaction Price for New Cars(2)
	(Current $)	(2000 $)	(Current $)	(2000 $)	(2000$)
1975	$129.90	$415.78	$386.00	$1,235.49	$336
1976	$15.60	$47.21	$198.00	$599.22	$553
1977	$59.15	$168.08	$382.30	$1,086.34	$124
1978	$50.12	$132.37	$424.49	$1,121.12	$327
1979	$46.35	$109.94	$300.30	$712.28	-$607
1980	$241.51	$504.71	$365.85	$764.56	-$412
1981	$530.85	$1,005.64	$536.14	$1,015.66	$1,051
1982	$126.32	$225.41	$562.64	$1,004.01	$769
1983	$128.04	$221.37	$263.92	$456.30	$689
1984	$110.08	$182.44	$221.70	$367.44	$516
1985	$151.45	$242.38	$268.20	$429.22	$92
1986	$186.50	$293.02	$745.52	$1,171.34	$933
1987	$47.13	$71.44	$776.38	$1,176.87	$413
1988	$245.56	$357.44	$458.66	$667.64	-$11
1989	$182.89	$253.98	$559.35	$776.77	-$323
1990	$216.40	$285.11	$804.91	$1,060.49	-$139
1991	$215.06	$271.90	$672.77	$850.59	-$253
1992	$259.79	$318.86	$917.30	$1,125.87	$485
1993	$89.10	$106.18	$616.54	$734.73	$55
1994	$363.63	$422.52	$612.74	$711.97	$697
1995	$173.35	$195.87	$543.21	$613.78	-$510
1996	$193.03	$211.85	$494.98	$543.25	$316
1997	$185.53	$199.05	$333.34	$357.64	$347
1998	$230.81	$243.84	$363.27	$383.77	$558
1999	$15.50	$16.02	$125.27	$129.48	-$161
2000	$169.05	$169.05	$408.42	$408.42	-$997
2001	$212.67	$206.79	$422.51	$410.82	$652
2002	$63.80	$65.38	$377.94	$361.76	NA

Sources: (1) U.S. Department of Labor, Reference 32 (2) U.S. Department of Commerce, Reference 26.

Figure 13 Average Changes in MSRP vs. Price Changes due to Quality Adjustments



Sources: U.S. Department of Labor, Reference 32 & U.S. Department of Commerce, Reference 26.

5. Consumer response

In this section of the report, the responses of consumers to changes in the characteristics and prices of the vehicles offered for sale by the auto industry are presented and analyzed based on historical trends in vehicle sales of various vehicle classes and macro-economic factors.

5.1 Historical review of vehicle sales

There are a number of sources (References 5,6, and 8) of vehicle sales information, including sales by class and vehicle characteristics, for the period 1970 to the present (2003). Such information is also available in the UC Davis Vehicle Data Base discussed in Section 3. Total sales of all light-duty vehicles and percent of sales by class are given in Table 5. As noted previously, the sales fractions of the larger light duty vehicles (vans, SUVs, and light trucks) have increased rapidly over the last ten years and are expected to increase further in the years ahead. At the present time (2003), the sales fraction of all cars has decreased to about 50% of the total vehicle sales. The sales fraction of mid-size cars has increased and that of small (subcompact and compact) cars has decreased over the years such that in 2000 the sales fraction for mid-size cars was 37% and that of small cars was 47% of the total automobiles sold. The sales fraction of small cars (subcompact and compact) peaked at 64.8% in 1988. Large cars are a relatively small percentage (15%) of the car market. About 23% of the cars sold in the United States in 2000 were imported. Import sales are largest in California and the Northeast. Total vehicle sales have fluctuated over the years, but with a general increase from about 14 million in the late 1970s to slightly over 17 million by 2000-2001.

All of the auto manufacturers offer multiple (two or three) versions of vehicles in each model group. The different vehicles in a model group can have different engines, transmissions, accessories, and/or interior/exterior trim. The key differences of interest in this study are those related to the powertrain – primarily the engine, which can significantly effect the emissions and fuel economy. In many instances, the model options are differentiated by the power rating of the engine and whether it is a 4-cylinder or V6 configuration. Information on sales of various models with different engines is given in Reference 3. Selected data from that database showing the sales breakdown for a number of car, van, and SUV models using different size engines are given in Table 7. Note that unless performance is clearly the prime consideration to the buyer, the majority of the car buyers opt to purchase models with the lower power 4 cylinder engines when they have a choice. Buyers of vans and SUVs tend to purchase higher power V6 engines even when 4 cylinder engines are available. Within each model group, there is a significant price difference of at least $2000-$3000. Sales data seem to indicate that buyers tend to prefer the lower price options in the model group, but as indicated in Table 7, there are still significant sales of the higher priced vehicles in the group. Hence buyers are willing to pay several thousand dollars more if they feel they are receiving higher value in the vehicle, especially when they feel that high power is necessary.

Table 7 Sales Breakdown by Engine & Cam Type for 2002 Model Year

	Type	Small Car	Large Car	Minivan	Small Truck	Large Truck
Engine	L4 Gasoline	73.04%	25.33%	2.90%	20.48%	
	L4 Diesel	0.97%				
	L6 Gasoline	4.92%	0.48%		15.41%	0.82%
	V6 Gasoline	16.43%	60.51%	97.10%	57.22%	16.02%
	V8 Gasoline	2.87%	13.59%		5.42%	83.16%
	V12 Gasoline	0.01%	0.08%			
Cam	OHV	13.30%	31.30%	68.00%	20.70%	59.20%
	SOHC	32.30%	23.60%	3.20%	27.10%	32.80%
	DOHC	54.40%	45.00%	28.80%	52.20%	8.00%

Source: Reference 3, Martech Database.

5.2 Historical review of the effect of fuel prices and macro-economic factors on vehicle sales

In the previous section, total vehicle sales and sales by vehicle class were reviewed for the period 1970-2002, but there was no consideration of why the sales varied as they did or how changes in model prices affected their sales. In this section, the influence of the various factors affecting sales are assessed qualitatively to evaluate consumer responses to them.

First consider the effect of fuel prices on vehicle sales and fraction of sales in the various vehicle classes. The variation in the price of gasoline from 1975-2001 is shown in Table 8 in terms of current dollars, 1970$, and 2001$. The general consumer price index (cpi) was used to relate the various dollars. The table indicates that in real dollars the price of gasoline has varied significantly and was a maximum during the period 1977-1982 and was relatively flat and low during 1990-1994. Hence the level and large increase in gasoline prices would be expected to be market drivers in 1977-82 and changes in gasoline prices less of a factor in 1990-1994. Table 9 indicates that in 1977-1982 the high gasoline prices resulted in a large shift in the sales of passenger cars to smaller cars with higher fuel economy- compact to subcompact and large to mid-size cars. In addition, as shown in Table 6, the sales of US manufactured cars decreased and the sales of imported cars increased from 1977-1982 as the market demanded smaller, high fuel economy cars. Total car sales decreased by about 30% during that period.

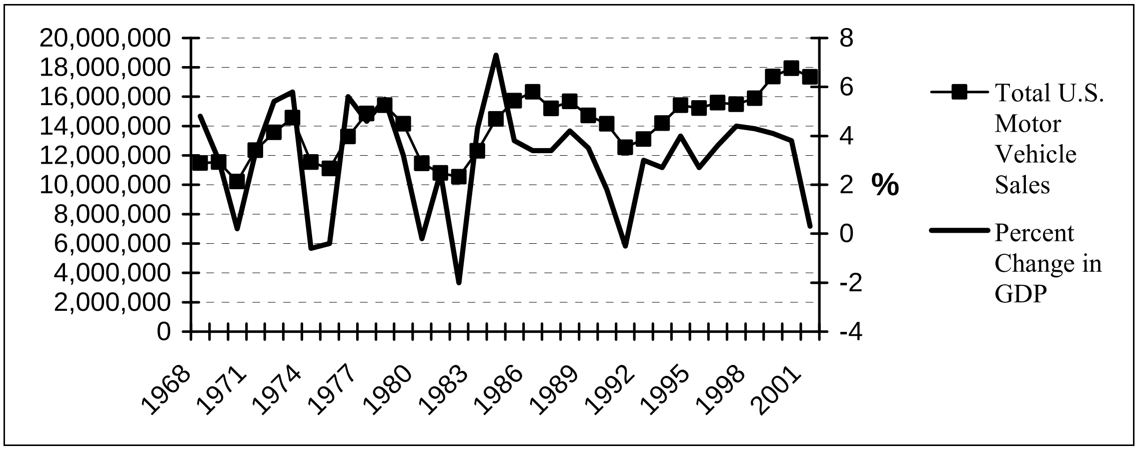
Table 8 Regular Unleaded Gasoline Prices during 1974-2002

Year	Unleaded Gasoline (current $/gal)	Unleaded Gasoline (1970$/gal)	Unleaded Gasoline (2001$/gal)
1974	$0.53	$0.43	$1.93
1975	$0.57	$0.42	$1.91
1976	$0.61	$0.42	$1.89
1977	$0.66	$0.41	$1.87
1978	$0.67	$0.38	$1.74
1979	$0.90	$0.48	$2.23
1980	$1.25	$0.59	$2.70
1981	$1.38	$0.62	$2.81
1982	$1.30	$0.56	$2.53
1983	$1.24	$0.50	$2.28
1984	$1.21	$0.46	$2.10
1985	$1.20	$0.44	$1.99
1986	$0.93	$0.32	$1.45
1987	$0.95	$0.31	$1.41
1988	$0.95	$0.29	$1.33
1989	$1.02	$0.30	$1.37
1990	$1.16	$0.32	$1.47
1991	$1.14	$0.30	$1.38
1992	$1.11	$0.30	$1.34
1993	$1.11	$0.29	$1.40
1994	$1.11	$0.29	$1.30
1995	$1.15	$0.29	$1.33
1996	$1.23	$0.31	$1.40
1997	$1.23	$0.30	$1.38
1998	$1.06	$0.25	$1.15
1999	$1.17	$0.27	$1.23
2000	$1.51	$0.34	$1.56
2001	$1.46	$0.32	$1.46
2002	$1.36	$0.29	$1.33

Source: U.S. Department of Energy, Reference 34.

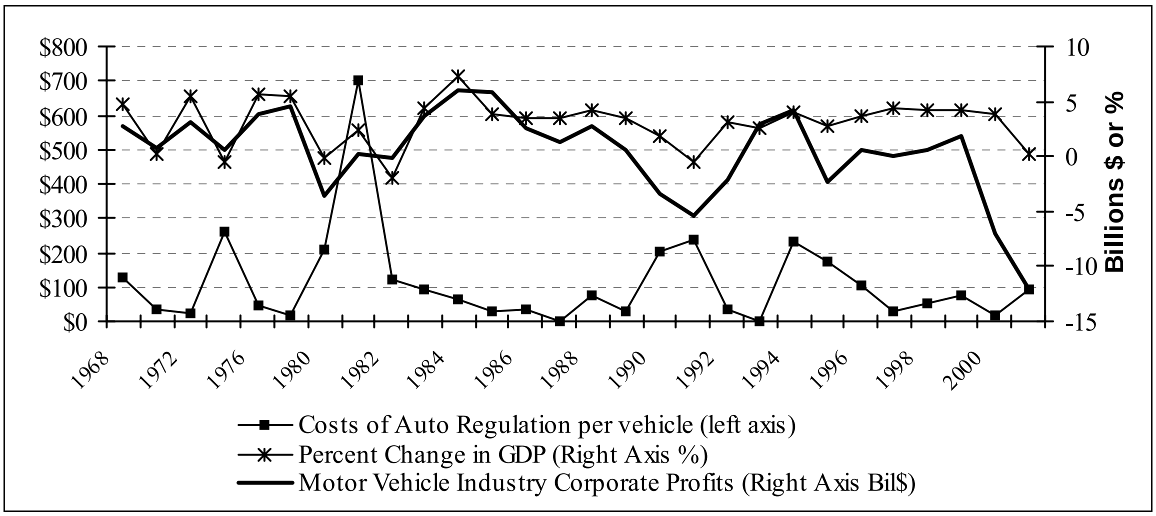
Next consider the effect of the growth rate (percent change in GDP) of the economy on vehicle production and sales. This effect is shown in Figure 14. Also indicated in the figure are the time periods 1977-1982 and 1990-1994 in which previous analysis in Section 4.3 indicated the vehicle price changes were the largest in response to changes in emissions, fuel economy, and/or safety regulations. Figure 14 indicates that increases in sales are strongly correlated with periods of economic expansion more or less independent of other factors. This correlation seems to hold even during periods in which vehicle prices had large increases. In the period 1977-1982, the economic growth rate was falling (a recession) and vehicle sales also decreased. However, for most of the period 1990-1994, the economy was expanding and vehicle production and sales increased even though the price of vehicles showed a significant increase. The effects of

Figure 14 Relationship of Domestic Motor Vehicle Sales(1) to the Overall Economy GDP(2)



Source: (1) Ward's Communications, Reference 25 (2) U.S. Department of Commerce, Reference 33.

Figure 15 Macro relationship between costs of regulation(1), industry corporate profits(2) and GDP



Source: (1) U.S. Department of Labor, Reference 32 (2) U.S. Department of Commerce, Reference 26.

economic growth and the cost of auto regulations on auto industry profits are shown in Figure 15. Industry profits decreased during the 1977-82 period and showed an increase during the later part of the 1990-94 period. This would be expected as during the first period sales decreased (especially those of US auto companies) and in the second period, sales increased. Hence Figures 14 and 15 indicate that the key factor in assessing the effect of changing regulations on vehicle sales and industry profitability is the status of the general economy when the changes are made. The changes should be made in a way that does not adversely affect economic growth.

The changes in the vehicle class sales fractions in the 1990-1994 period were very different that those that occurred in the 1977-1982 (see Table 9). The primary shifts were from subcompact to compact cars and the beginning of the purchase in large numbers of SUVs. The market share of SUVs nearly doubled between 1990 and 1995 and increased further by another 50% by 2000. Gasoline prices were low and stable in this period and buyers were clearly not concerned about fuel economy of the vehicles

Table 9 Light-Duty Vehicle Market Shares by Size Class (1976 - 2001)

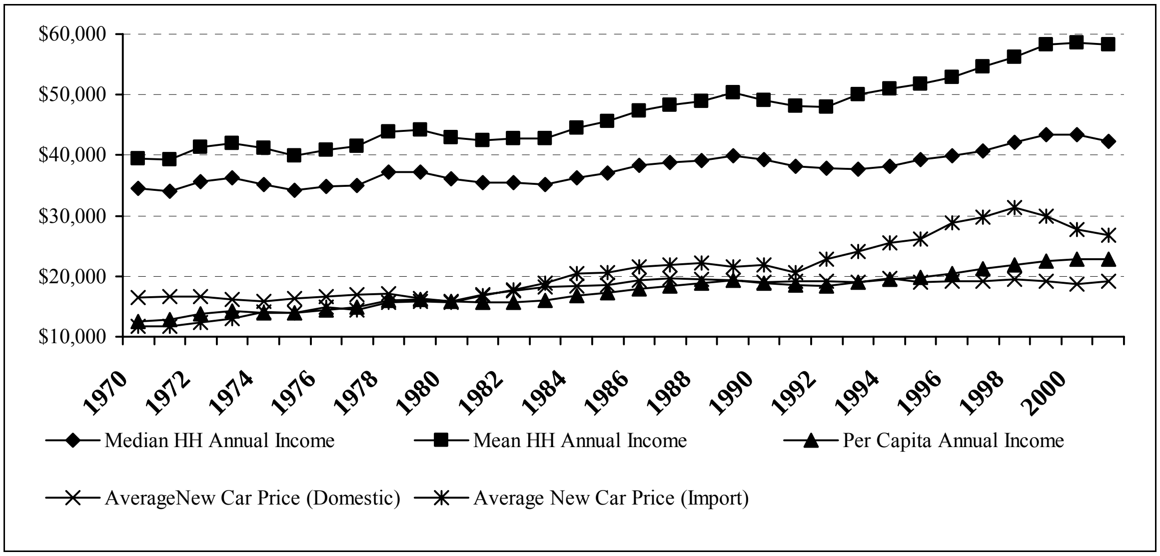
Year	Minicompact	Subcompact	Compact	Midsize	Large	Two Seater	Percent of Light Vehicles Total
1976	0.0%	21.7%	23.5%	15.0%	18.3%	1.7%	80.2%
1977	6.5%	15.5%	21.8%	15.6%	20.0%	1.7%	81.0%
1978	6.7%	15.0%	12.0%	26.1%	17.6%	1.5%	79.0%
1979	4.3%	24.4%	6.7%	26.9%	15.4%	1.7%	79.4%
1980	3.8%	30.4%	5.3%	27.2%	11.8%	1.9%	80.4%
1981	3.9%	31.2%	5.4%	27.9%	12.1%	2.0%	82.5%
1982	2.7%	26.6%	10.8%	28.3%	10.1%	2.2%	80.6%
1983	2.1%	23.2%	12.6%	24.5%	9.6%	2.0%	74.0%
1984	0.3%	18.2%	20.0%	22.1%	10.9%	2.4%	73.9%
1985	0.3%	15.7%	23.2%	20.5%	10.0%	2.5%	72.1%
1986	1.2%	15.9%	23.6%	19.1%	9.4%	1.8%	71.0%
1987	1.0%	13.6%	27.1%	16.9%	9.3%	1.6%	69.5%
1988	0.6%	13.1%	27.8%	16.9%	9.1%	1.2%	68.6%
1989	0.1%	13.1%	24.7%	19.7%	9.4%	1.1%	68.1%
1990	0.6%	14.8%	23.0%	18.3%	9.3%	1.2%	67.1%
1991	0.6%	17.5%	19.8%	18.8%	9.4%	1.1%	67.1%
1992	0.9%	16.6%	19.6%	18.0%	9.1%	0.7%	64.9%
1993	0.6%	14.5%	19.8%	18.2%	8.8%	0.5%	62.4%
1994	0.4%	13.8%	21.0%	16.1%	9.2%	0.5%	60.9%
1995	0.3%	10.4%	22.4%	17.0%	9.0%	0.4%	59.5%
1996	0.2%	8.8%	23.5%	16.7%	8.5%	0.4%	58.1%
1997	0.3%	10.2%	19.9%	17.1%	7.9%	0.5%	55.9%
1998	0.1%	9.8%	15.2%	20.4%	6.9%	0.7%	53.1%
1999	0.1%	9.7%	14.2%	20.2%	7.1%	0.6%	51.9%
2000	0.1%	10.4%	13.9%	19.4%	7.5%	0.7%	51.9%
2001	0.2%	5.6%	18.7%	16.3%	9.2%	0.7%	50.9%

Source: TEDB 22, Reference 8.

they were purchasing. In general, buyers also seemed not to be concerned with the relatively large price increases ($1000-$2000 per model year) that often occurred in 1990-1994.

Another economic factor that could be expected to influence the response of consumers to vehicle price increases is the income of families. The change in the mean and median income of families in the period 1970-2002 is shown in Figure 16. Since the early 1980s, the mean income has increased more rapidly than the median income indicating the income of more affluent families has increased faster than the lower income families. The average prices of new domestic and imported cars are also shown in Figure 16. Percentage-wise the prices of cars have increased more rapidly than family incomes over most of the period of interest. Note that after about 1990 the average price of domestic cars has leveled off, but the average prices of imported cars have continued to increase at a relatively fast rate. These trends can also be seen in the cost data given in Appendix 2 for the various vehicle models. In the case of SUVs, the prices of the vehicles in real dollars have been nearly level or even decreasing. The more rapid increase of the mean income and the relatively level price of SUVs may explain why the more expensive car models and SUVs have sold so well and are gaining a greater share of

Figure 16 Trends in Annual Income and New Car Prices ($2001)



Source: (1) U.S. Department of Commerce & U.S. Census Bureau, References 26 & 30.

the vehicle market. Further discussion of how consumers have coped with the increasing cost of new vehicles is given in the next section.

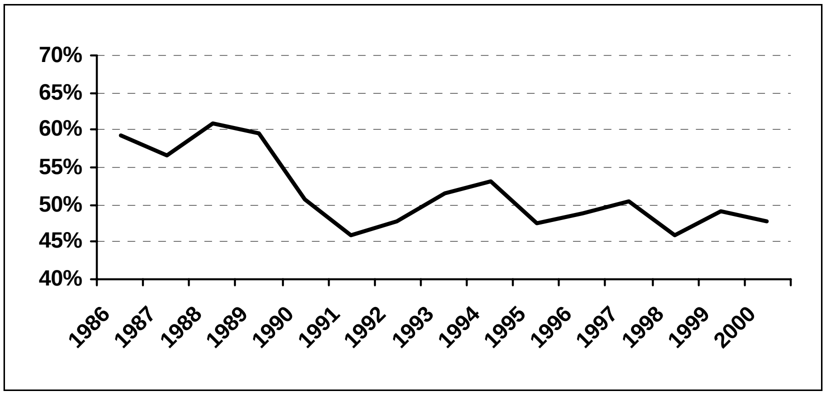
5.3 Historical review of innovative financing and marketing strategies

Automakers and dealers have increasingly used flexible financing plans and incentives to maintain high sales volumes even during economic downturns. These marketing strategies have undergone a crescendo in the aftermath of September 11th as evidenced by a proliferation of zero percent financing and rebates as high as $5000. In October 2002 it was reported that the Big 3 automakers were spending an average of $3,764 per vehicle, or 14 percent of the selling price, on all types of incentives (Reference 36).

Cut-rate financing and cash rebates are nothing new for the auto industry. These measures began in the mid-1970s as a means to move end-of-the-year inventory and particularly slow-selling models. Such marketing approaches have remained a way to reduce inventory and maintain market share, and have not been a means for generating higher total revenues. The excess capacity in the auto industry, particularly for the domestic carmakers, explains why the auto companies would continue to build more supply than normal expected demand. This excess demand is created through generous incentives. Bill Lovejoy, V.P. of GM, summed up this concept in stating that, “incentives will stay in place until demand is more aligned to capacity.” Figure 17 shows the trend in capacity utilization for the production of autos and light trucks in the U.S.

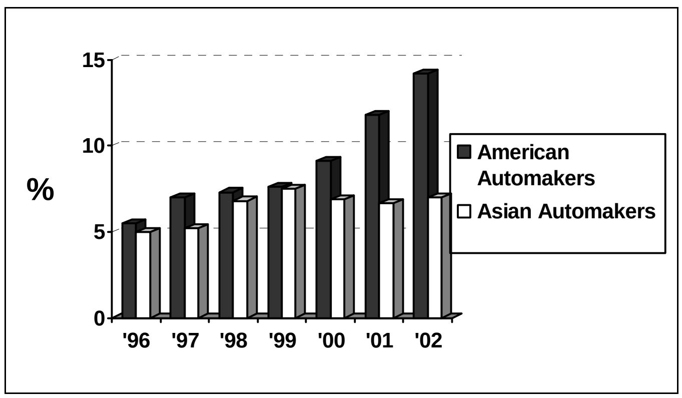
There are two types of rebates used in the auto industry: (1). manufacturer rebates (e.g. the auto manufacturer gives the customer a $1,000 rebate upon the purchase of a specific vehicle, which the customer assigns as reduction to the purchase price), and (2) dealer rebates (e.g. an auto dealer receives a $500 incentive from the auto manufacturer for every vehicle sold of a specific model in a given period). In the case (1), the rebate is part of the dealer’s gross receipts, while in the second example, it is not. American automakers in particular have increased incentives markedly over the last few years

Figure 17 Ratio of the Utilization Index to the Capacity Index for Auto Production in the US



Source: (1) U.S. Department of Commerce, Reference 26.

Figure 18 Incentives as a Percentage of Sales Price (1996-2002)

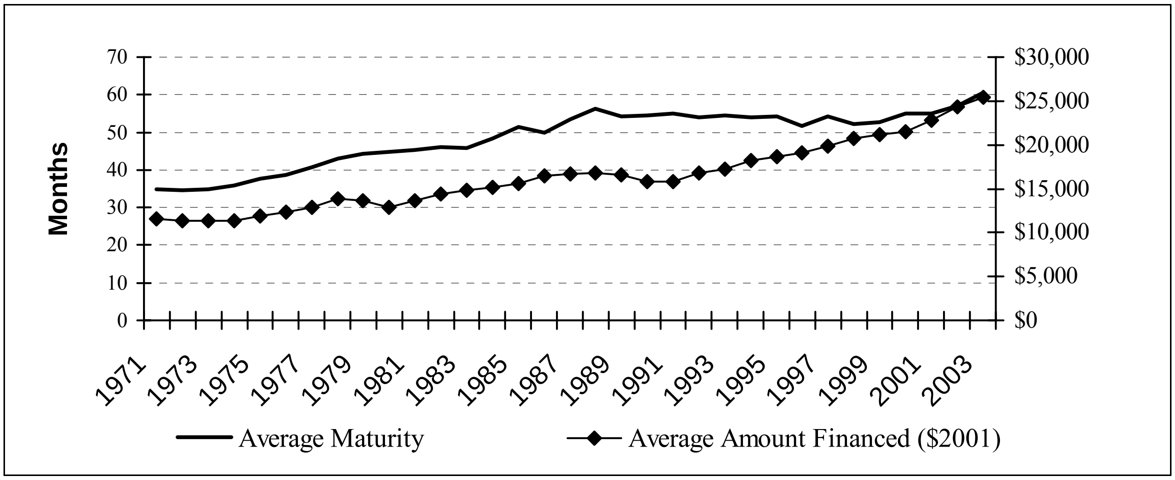


Source: CNW Marketing/Research, Reference 31.

(Figure 18). General Motors, the acknowledged bellwether with regard to incentives, has gone so far as to offer its 159,000 U.S. employees, and tens of thousands of employees at GM suppliers and dealers, a $1,000 discount on a new car or truck in an attempt to boost vehicle sales in September 2003 (Reference 37). Automakers use incentives other than cash to motivate consumers. For instance, GM offered a free Dell™ computer system with the purchase or leasing of a 2003 model year Saturn car or truck during September 2003 in addition to the incentives already in place (Reference 39).

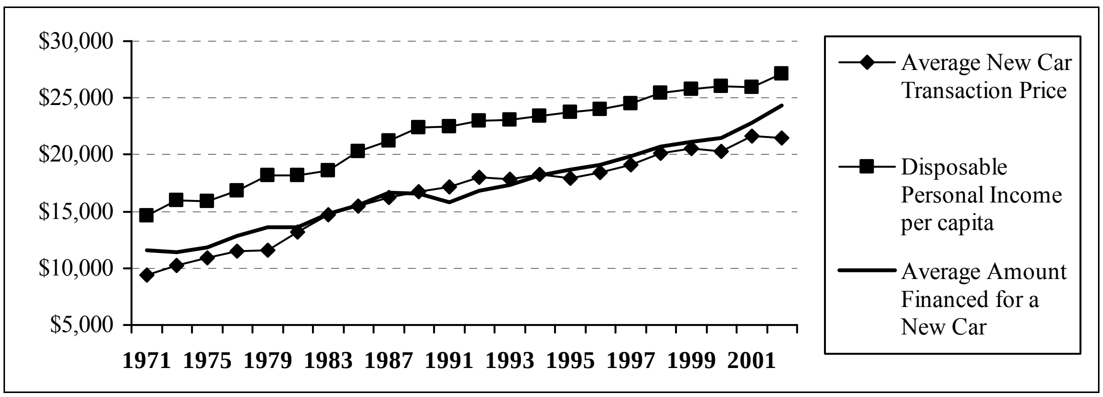
Changes in financing options have also made cars increasingly affordable to consumers whose incomes have been increasing slower than the price of new cars. Figure 19 shows that the average maturity rate for auto loans has nearly doubled over the last 32 years, while Figure 20 indicates that the car price, the amount financed, and disposable personal income all in constant dollars have tracked closely together. Monthly payments are thus smaller and more manageable for the consumer.

Figure 19 Average Amount Financed for a New Car and Average Maturity Rate of Auto Loans



Source: (1) U.S. Department of Commerce, Reference 26.

Figure 20 Trends in New Car Financing and Pricing; And in Disposable Income ($2001)



Source: U.S. Department of Commerce & U.S. Census Bureau, References 26 & 30. Table Notes: Disposable income is the amount of Personal income an individual has after taxes and government fees, which can be spent on necessities, or non-essentials, or be saved. Figure data are every other year preceding 1991 and every year thereafter.

Although most car loans are between 36 and 60 months, a number of independent finance companies in the western United States have recently offered loans as long as 96 months (Reference 38). The maturity rate for car loans has stabilized considerably since the mid to late 1980s, but recent record low interest rates provide the greater flexibility for potentially longer term car loans.

In addition to amenable loan terms and interest rates, lease financing has flourished in the last 15 years. Table 10 highlights the dramatic increase in the lease penetration rate from 3.5 percent of new vehicle transactions in 1985 to 31.5 percent in 2002. Leasing allows the consumer to have lower affordable monthly payments and the opportunity to receive a new vehicle every 3 to 5 years.

Table 10 U.S. Market Lease Penetration Rates by Vehicle Segment

Segment	1985	1990	1995	1996	1997	1998	1999	2000	2001	2002
Passenger Cars										
Budget	2.2	5.5	12.1	13.6	13.4	12.1	12.0	10.3	10.0	9.7
Small	1.8	5.3	18.9	18.5	15.4	14.8	14.4	14.2	12.1	10.4
Lower Middle	8.2	12.8	26.9	27.3	28.1	27.3	27.2	25.7	24.5	22.2
Core Middle	11.5	16.2	30.4	31.8	31.1	28.6	27.3	26.9	26.3	25.7
Upper Middle	11.5	14.7	26.2	27.3	28.1	29.1	29.4	29.2	30.0	31.9
Near Luxury	16.6	25.2	50.5	52.6	57.3	58.3	58.8	59.7	58.9	60.2
Luxury	39.6	52.6	62.0	64.2	65.9	65.2	57.8	51.3	55.5	58.8
Specialty	11.1	24.6	59.7	61.3	58.5	57.5	55.3	50.4	52.3	51.1
Sport	16.2	18.8	26.2	30.4	34.4	39.3	40.2	41.1	44.4	47.8
Light Trucks										
Compact Pickup	1.3	4.4	14.6	15.2	16.3	15.7	15.6	15.7	15.8	16.1
Compact SUV	5.2	9.6	34.3	36.7	38.4	39.7	41.2	40.7	42.2	44.7
Full Size Pickup	4.6	8.2	18.3	19.4	22.7	25.3	28.1	26.3	27.1	27.3
Full Size SUV	4.2	9.3	36.9	38.2	42.1	42.7	44.4	46.5	45.9	46.7
Full Size Van	7.1	12.1	20.0	21.3	22.7	22.4	21.9	21.1	21.0	20.7
Minivan	4.2	8.4	25.8	28.1	32.8	33.5	35.7	32.3	36.6	37.3
Total	3.5	7.3	24.2	27.2	29.3	31.5	29.1	28.7	29.2	31.5

Source: CNW Marketing/Research, Reference 31. Table Notes: Figures shown are estimates representing lease transactions as a percent of new vehicle retail transactions. The total of all segments combined is based on a weighted average.

References

References for the Literature Review Section (1.1)

Gerard, David and Lester Lave, "Implementing Technology-Forcing Policies: The 1970 Clean Air Act Amendments and the Introduction of Advanced Automotive Emissions Controls," Center for the Study and Improvement of Regulation, Department of Engineering and Public Policy, Carnegie Mellon University, May 2003
.
Gómez-Ibáñez, José A., William B. Tye, editor, Clifford Winston, Eds., *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer*, The Brookings Institution Press: Washington, DC, 1999.

Crandall, Robert W. et al., *Regulating the Automobile*, The Brookings Institution Press: Washington, DC, 1986.

Schnapp, John B., *Corporate Strategies of the Automotive Manufacturers,* Prepared for U.S. DOT, NHTSA. Contract No. DOT HS-7-01783, November 1978.

Donnelly, Julie H., *Use of Advertising and Marketing Incentives to Promote Sales of Fuel Efficient Vehicles,* Prepared for the U.S. DOT. Contract No. DTNH22-80-C-07131, June 1981.

Motor vehicle regulations: Regulatory cost estimates could be improved, Report to the Chairman, Subcommittee on Oversight and Investigations, Committee on Energy and Commerce, House of Representatives. United States General Accounting Office, 1992.

Assessing regulatory impacts: The Federal experience with the auto industry, Submitted to United States Regulatory Council, ICF Incorporated. Contract No. CORC 02, March 1981.

Mondt, J. Robert, *Cleaner Cars: The History and Technology of Emission Control Since the 1960s*, SAE International, 2000.

Bresnahan, Timothy F. and Dennis A. Yao. "The nonpecuniary costs of automobile emissions standards." *Rand Journal of Economics*, Vol. 16, No. 4, 437-455, Winter 1985.

Wang, Quanlu, Catherine Kling, and Daniel Sperling. 1993. "Light-Duty Vehicle Exhaust Emission Control Cost Estimates Using a Part-Pricing Approach." *J. A ir Waste Manage. Assoc.* 43, 1461-1471, 1993.

Anderson, John F. and Todd Sherwood. “Comparison of EPA and Other Estimates of Mobile Source Rule Costs to Actual Price Changes,” *SAE Publication* 2002-01-1980, 2002.

Chen, Belinda et al. “Effect of Emissions Regulation on Vehicle Attributes, Cost, and Price,” Institute of Transportation Studies, Report for the California Air Resources Board, December 2003.

Graham, John. “Technology, Behavior and Safety: An Empirical Study of Automobile Occupant-Protection Regulation.” *Policy Sciences* 17, 141-51, October 1984.

Gomez-Ibanez, Jose A. “Recission of the Passive Restraints Standard: Costs and Benefits.” C16-83-562. Harvard University, Kennedy School of Government Case Program, 1997.

Mannering, Fred and Clifford Winston. “Automobile Air Bags in the 1990s: Market Failure or Market Efficiency,” *Journal of Law and Economics,* Vol. XXXVIII, pp. 265-279, October 1995.

Peltzman, Sam. “The Effects of Automobile Safety Regulation.” *Journal of Political Economy* 83, 677-725, 1975.

Arnould, R., and Grabowski, H. “Auto Safety Regulation: An Analysis of Market Failure,” *The Bell Journal of Economics 12*, No. 27, 1981.

Dunham, W. R. “Are automobile safety regulations worth the price: Evidence from used car markets.” *Economic Inquiry 35,* No. 3, 579-589, 1997.

Abeles, Ethan et al. “Automaker Response to Passive Restraint Regulation with respect to Actions, Economics, Technology and Marketing.” Institute of Transportation Studies, Report for the California Air Resources Board, December 2003.

Gsellman, L. R. "The 1981-84 Automobile Fuel-Economy Standards - Can They Be Achieved." *Applied Energy* 8(3): 143-173, 1981.

Mcnutt, B. D. "United-States Automobile Fuel-Economy Policies and Consumption Effects." *Resources and Conservation* 10(1-2): 9-24, 1983.

Leone, R.A. and T.W. Parkinson *Conserving Energy: Is There a Better Way? A Study of CAFE Regulation.* Association of International Automobile Manufacturers. Washington DC, 1990.

Porter, Richard C. *Economics at the Wheel.* Academic Press: San Diego, 1999.

Falvey, R. E., J. Frank, et al. "Fuel-Economy Standards and Automobile Prices." Journal of *Transport Economics and Policy* 20(1): 31-45, 1986.

Thorpe, S. G. "Fuel economy standards, new vehicle sales and average fuel efficiency." *Journal of Regulatory Economics* 11(3): 311-326, 1997

Goldberg, P. K. "The effects of the Corporate Average Fuel Efficiency Standards in the US." *Journal of Industrial Economics* 46(1): 1-33, 1998.

Espey, M. "Pollution control and energy conservation: Complements or antagonists? A study of gasoline taxes and automobile fuel economy standards." *Energy Journal* 18(2): 23-38, 1997
.
Crandall, R. W. and J. D. Graham "The Effect of Fuel-Economy Standards on Automobile Safety." *Journal of Law & Economics* 32(1): 97-118, 1989
.
Dowlatabadi, H., L. B. Lave, et al. "A free lunch at higher CAFE? A review of economic, environmental and social benefits." *Energy Policy* 24(3): 253-264, 1996.

Ross, M. "Automobile Fuel Consumption and Emissions - Effects of Vehicle and Driving Characteristics." *Annual Review of Energy and the Environment* 19: 75-112, 1994.

General References for the report (numbered)

1.Mondt, J.R., Cleaner Cars: The History and Technology of Emissions Control since the 1960s, book, SAE Publications, 2000
2. EPA emissions and fuel economy test data, emissions: epa.gov/otaq; fuel economy: fueleconomy.gov/feg/download.shtml
3. MarTech data base from ARB
4. Burke, A. F. and Kurani, K., Study of the Secondary Benefits of the ZEV Mandate, Report No. UCD-ITS-RR-00-7, August 2000
5. Light-duty Automotive Technology and Fuel Economy Trends 1975 through 2000, Report EPA 420-R00-008, December 2000
6. Market Data Book-2003, published by the Automotive News, 2003
7. Abeles, E., Air Bag Thesis, 2003
8. Davis, S.C., Transportation Energy DataBook, Editions 17, 20, 21, 22, published by the Center for Transportation Analysis, Oak Ridge National Laboratory. See: http://www-cta.ornl.gov/cta/data/Index.html
9. Buchholz, K., Why Diesel, Why Now?, SAE Automotive Engineering International, August 2003
10. Ashley, S., Diesel cars come clean, Mechanical Engineering, Vol.119, No.8, August 1997
11. Tomazic, D., integration of Emission Control Systems for CIDI Engines to Achieve PZEV, PZEV Emissions Technology: Regulations and Challenges, SAE TOPTEC, January 24-25, 2002, San Diego, California

12. Johnson, J. H., Diesel Nitrogen Oxide Emissions –Landmark Research 1995-2001, SAE Publication PT-89, 2002
13. Johnson, J. H., Diesel Particulate Emissions-Landmark Research 1994-2001, SAE Publication PT-86, 2002
14. “No diesel without Filter Campaign”, Diesel Fuel News, May 12, 2003, Page 1-5
15. Diesel Car magazine, published in the UK, June 2001
16. Cars Road Tests 2003-Winners and Losers, published by Consumers Report, Spring 2003
17. New Car Preview-2002: Ratings, Reviews, and Reliability, published by Consumers Reports, Winter 2002
18. Hermance, D., Toyota Hybrid System, 1999 SAE TOPTEC conference, Albany, N.Y., May 1999
19. Hirose, T., Takaoka, T.,Ueda, T., and Kobayashi, Y., the New High Expansion Ration Gasoline Engine for the Toyota Hybrid System, JSAE paper 9739552, October 1997
20. Ogawa, H., Masato, M., and Takahiro, E., Development of a Power Train for the Hybrid Automobile-The Civic Hybrid, SAE paper 2003-01-0083, March 2003
21. Burke, A. F., Saving Petroleum with Cost-effective Hybrids, SAE paper 2003-01-3279, November 2003
22. An, F. and Santini, D., Mass Impacts on Fuel Economies of Conventional vs. Hybrid Vehicles, paper to be presented at the 2004 SAE World Congress, March 2004
23. Description and Rationale for Staff’s Additional Proposed Modifications to the January 10, 2003 ZEV Regulatory Proposal, California Air Resources Board, March 5, 2003
24. Consumer Guide-Cars and Trucks, June 2003, published by Publications International, Lincolnwood, Illinois
25. Ward’s Communications, Ward’s Automotive Yearbook. Annual. New York: Primedia, Inc., 1970-2002.
26. U.S. Department of Commerce, Bureau of Economic Analysis, Office of Automotive Affairs. See: http://www.ita.doc.gov/td/auto/qfact.html.
27. U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index—All Urban Consumers, http://www.bls.gov/cpihome.htm.
28. U.S. Census Bureau, Historical Income Tables - Households, See: http://www.census.gov/hhes/income/histinc/h05.html.
29. Hellman, Karl H. and Heavenrich, Robert M., Light-Duty Automotive and Fuel Economy Trends: 1975 through 2003. U.S. Environmental Protection Agency, Office of Mobile Sources, April 2003. (EPA420-R-03-006) See: http://www.epa.gov/otaq/cert/mpg/fetrends/r03006.pdf.
30. U.S. Department of Commerce, Bureau of Economic Analysis, Disposable Personal Income, Series: DSPI. A Guide to the National Income and Product Accounts of the United States (NIPA, See: http://www.bea.doc.gov/bea/an/nipaguid.pdf.
31. CNW Marketing/Research, See: http://www.nvo.com/cnwmr/door/.
32. U.S. Department of Labor, Bureau of Labor Statistics, “Quality Adjustment Releases for Motor Vehicles,” 1975-2002, See: http://www.bls.gov/ppi/ppicarqa.htm.
33. U.S. Department of Commerce, Bureau of Economic Analysis, National Economic Accounts. See: http://www.bea.doc.gov/bea/dn/home/gdp.htm.

34. U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review,* 2002, Washington, D.C.
35. Ward's Automotive Reports, September 22, 2003.
36. “U.S. Carmakers Losing Ground to Imports, Despite Deals,” The New York Times, October 23, 2002, p. 1.
37. “GM Adds Employee Incentives to Boost Vehicle Sales,” Automotive News, September 25, 2003. See: http://www.autonews.com/news.cms?newsId=6478&bt=incentive.
38. “Car loans stretch to 8 years,” Automotive News, September 22, 2003.
39. “GM’s Saturn to Offer Dell Computers with Saturns,” Automotive News, September 5, 2003.

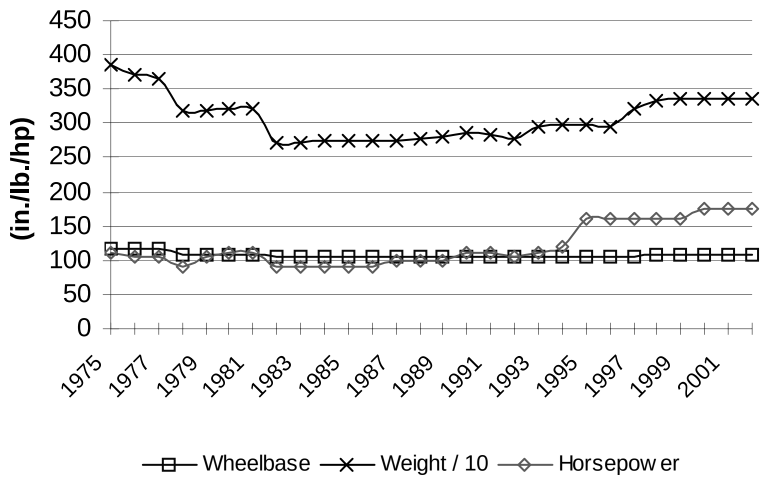
Appendices

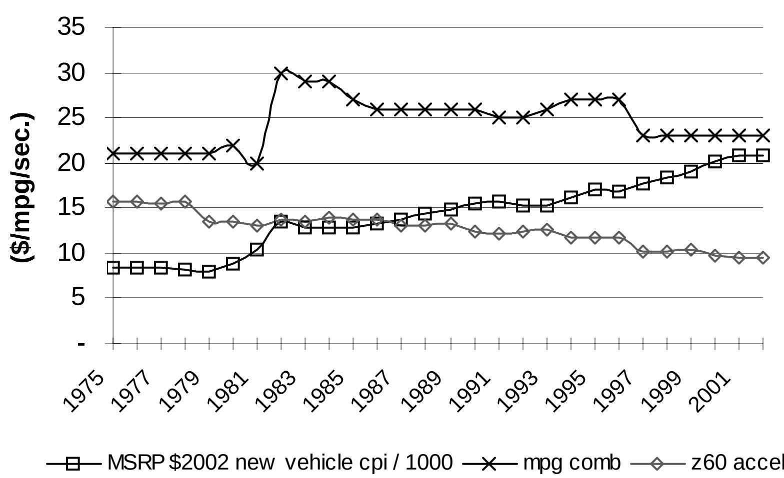
Appendix I: Timeline of new technologies to reduce emissions and improve fuel economy

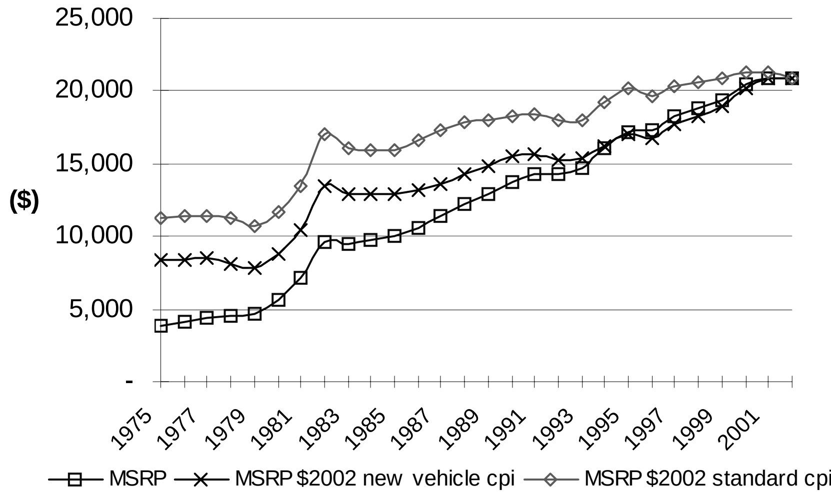
Year	Technology	Comments
1975	Two-way oxidation catalyst	Needed to meet the 1975 HC and CO standards
1975 – 1982	Weight reduction by downsizing and use of light weight materials	Needed to meet the CAFE standards (1978 – 1985?)
1976 – 1980	Improved radial tires and reduced aerodynamic drag	Lower road load
1977 – 1980	Electronic engine controls	Reduce emissions (NO_x)
1978 – 1985	Front-wheel drive in many models	Improve driveline packages and reduce weight
1978 – 1990	4-speed automatic transmission with lockup	Improve fuel economy
1980 -	V6 engines	New high power engine replacing some V8s
1980	Three-way, oxidation / reduction catalyst	Needed to meet the 1981 emissions standard (particularly NO_x)
1980	Electronic ignition and single-point fuel injection	Needed by the three-way catalyst to control A/F ratio
1982 – 1985	Computer control of the engine and transmission	Reduce emissions and fuel economy
1985	Multi-point fuel injection	Further reduce emissions
1986 – 1995	Use of 4-valves per cylinder in engines	Increase specific power (kW/Liter) of the engine and improve part-load bsfc
1995	Variable valve actuation and timing	Further improve emissions and fuel economy
2000	5- and 6-speed automatic transmissions with lockup in multiple gears	Improve fuel economy and acceleration performance
2000	Ultra-clean emission control	Meet ULEV and SULEV emissions standards
2000	Continuously Variable Transmission (CVT)	The engine speed/drive wheel speed ratio can be altered to enhance vehicle performance or fuel economy.

Appendix II: Detailed history of the performance and price of selected vehicle models

Buick Century – Midsize Car



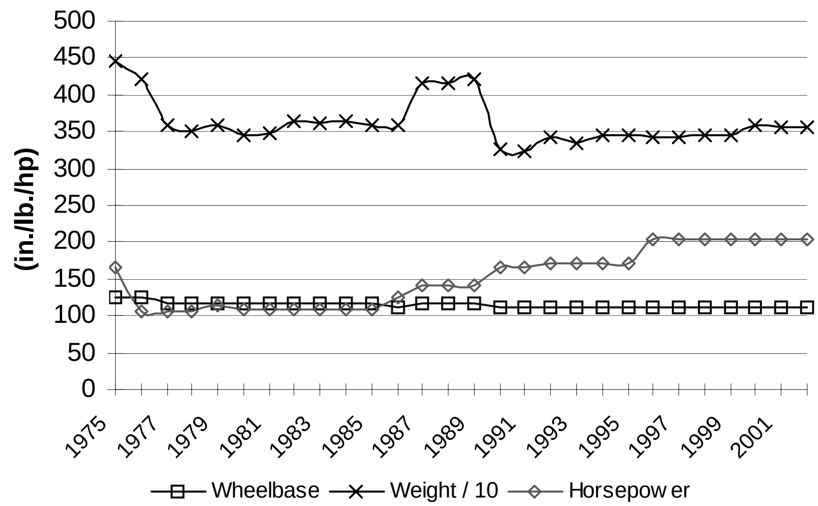


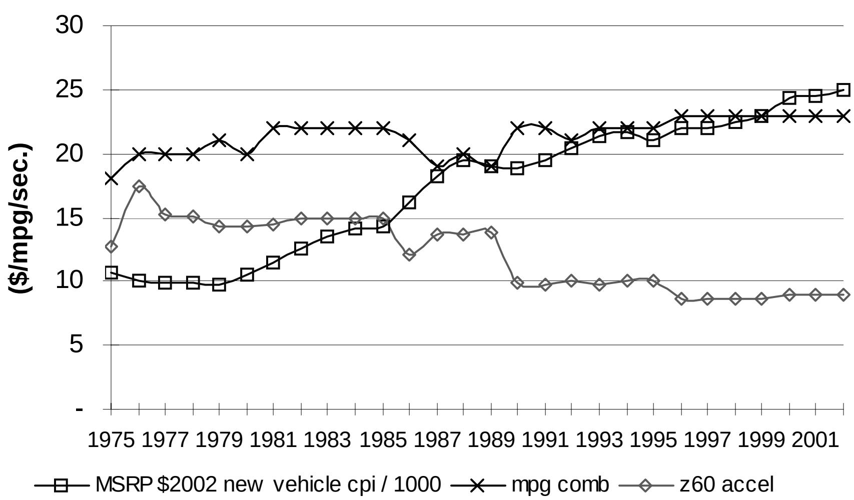


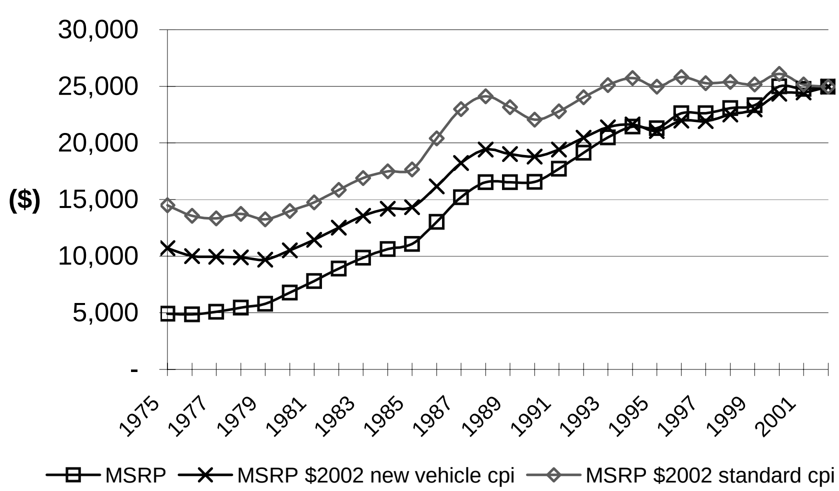
Buick Century

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	116	3869	110	$ 3,828	$ 8,356	$ 11,292	6	.	.	21	15.7
1976	116	3712	105	$ 4,105	$ 8,425	$ 11,435	6	.	.	21	15.7
1977	116	3645	105	$ 4,363	$ 8,509	$ 11,421	6	.	.	21	15.5
1978	108	3172	90	$ 4,486	$ 8,126	$ 11,271	6	3.2	A	21	15.7
1979	108	3172	105	$ 4,699	$ 7,887	$ 10,778	6	3.2	M3	21	13.6
1980	108	3201	110	$ 5,646	$ 8,769	$ 11,665	6	3.8	A3	22	13.5
1981	108	3201	110	$ 7,094	$ 10,395	$ 13,410	6	3.8	M3	20	13.2
1982	105	2712	90	$ 9,581	$ 13,506	$ 17,078	4	2.5	A3	30	13.8
1983	105	2712	92	$ 9,416	$ 12,941	$ 16,123	4	2.5	A3	29	13.6
1984	105	2738	90	$ 9,697	$ 12,951	$ 15,975	4	2.5	A3	29	13.9
1985	105	2738	92	$ 9,959	$ 12,888	$ 15,884	4	2.5	L3	27	13.7
1986	105	2754	92	$ 10,642	$ 13,211	$ 16,654	4	2.5	L3	26	13.8
1987	105	2753	98	$ 11,403	$ 13,662	$ 17,251	4	2.5	L3	26	13.1
1988	105	2762	98	$ 12,218	$ 14,350	$ 17,836	4	2.5	L3	26	13.1
1989	105	2792	98	$ 12,879	$ 14,835	$ 18,038	4	2.5	L3	26	13.2
1990	105	2869	110	$ 13,700	$ 15,546	$ 18,267	4	2.5	L3	26	12.3
1991	105	2832	110	$ 14,265	$ 15,631	$ 18,359	4	2.5	L3	25	12.2
1992	105	2790	110	$ 14,295	$ 15,286	$ 17,959	4	2.5	L3	25	12.5
1993	105	2949	110	$ 14,705	$ 15,354	$ 18,021	4	2.2	L3	26	12.6
1994	105	2974	120	$ 16,020	$ 16,173	$ 19,232	4	2.2	L3	27	11.8
1995	105	2993	160	$ 17,220	$ 17,009	$ 20,188	6	3.1	L4	23	10.4
1996	105	2950	160	$ 17,260	$ 16,760	$ 19,703	6	3.1	L4	23	10.4
1997	105	3215	160	$ 18,225	$ 17,765	$ 20,363	6	3.1	L4	23	10.3
1998	109	3335	160	$ 18,765	$ 18,312	$ 20,666	6	3.1	L4	23	10.3
1999	109	3353	160	$ 19,335	$ 19,016	$ 20,858	6	3.1	L4	23	10.3
2000	109	3368	175	$ 20,440	$ 20,205	$ 21,336	6	3.1	L4	23	9.6
2001	109	3353	175	$ 20,895	$ 20,895	$ 21,235	6	3.1	L4	23	9.6
2002	109	3353	175	$ 20,895	$ 20,895	$ 20,895	6	3.1	L4	23	9.6

Buick LeSabre – Large Car



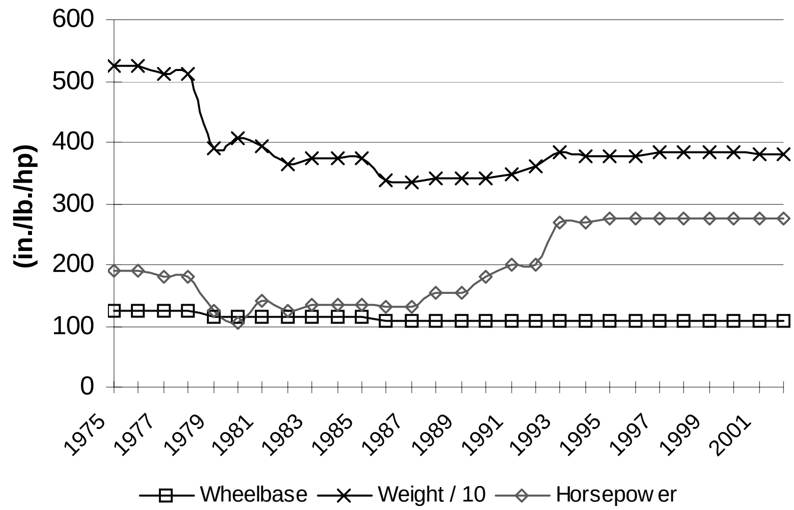


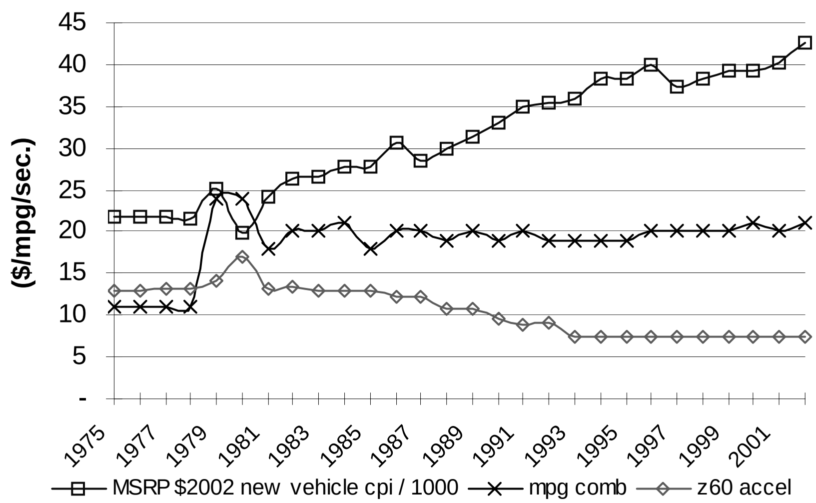


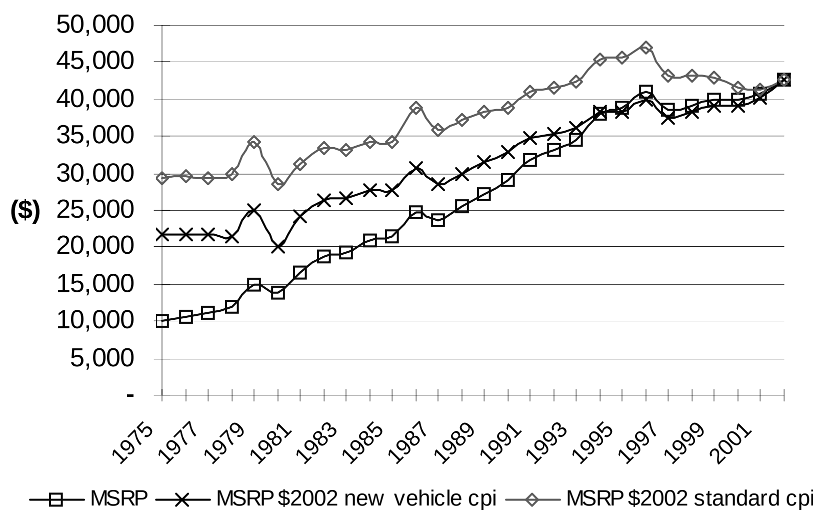
Buick LeSabre

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	124	4449	165	$ 4,911	$ 10,720	$ 14,487	8	.	.	18	12.7
1976	124	4210	105	$ 4,871	$ 9,997	$ 13,568	6	.	.	20	17.4
1977	116	3577	105	$ 5,092	$ 9,931	$ 13,330	6	.	.	20	15.3
1978	116	3510	105	$ 5,459	$ 9,888	$ 13,716	6	3.8	A	20	15.0
1979	116	3600	115	$ 5,780	$ 9,702	$ 13,257	6	3.8	A3	21	14.3
1980	116	3459	110	$ 6,769	$ 10,513	$ 13,986	6	3.8	A3	20	14.3
1981	116	3485	110	$ 7,805	$ 11,437	$ 14,754	6	3.8	A3	22	14.4
1982	116	3649	110	$ 8,886	$ 12,526	$ 15,840	6	3.8	A3	22	15.0
1983	116	3620	110	$ 9,869	$ 13,564	$ 16,899	6	3.8	A3	22	14.9
1984	116	3649	110	$ 10,615	$ 14,177	$ 17,488	6	3.8	A3	22	15.0
1985	116	3587	110	$ 11,078	$ 14,336	$ 17,668	6	3.8	L3	22	15.0
1986	111	3600	125	$ 13,026	$ 16,171	$ 20,385	6	3	L4	21	12.0
1987	116	4160	140	$ 15,199	$ 18,210	$ 22,994	8	5	L4	19	13.7
1988	116	4160	140	$ 16,520	$ 19,403	$ 24,117	8	5	L4	20	13.7
1989	116	4209	140	$ 16,530	$ 19,015	$ 23,151	8	5	L4	19	13.8
1990	111	3270	165	$ 16,555	$ 18,785	$ 22,073	6	3.8	L4	22	9.9
1991	111	3231	165	$ 17,715	$ 19,412	$ 22,799	6	3.8	L4	22	9.8
1992	111	3417	170	$ 19,125	$ 20,451	$ 24,026	6	3.8	L4	21	10.0
1993	111	3343	170	$ 20,490	$ 21,394	$ 25,110	6	3.8	L4	22	9.8
1994	111	3449	170	$ 21,435	$ 21,640	$ 25,732	6	3.8	L4	22	10.1
1995	111	3442	170	$ 21,309	$ 21,048	$ 24,981	6	3.8	L4	22	10.1
1996	111	3430	205	$ 22,620	$ 21,964	$ 25,822	6	3.8	L4	23	8.6
1997	111	3430	205	$ 22,620	$ 21,918	$ 25,274	6	3.8	L4	23	8.6
1998	111	3443	205	$ 23,070	$ 22,513	$ 25,407	6	3.8	L4	23	8.6
1999	111	3443	205	$ 23,340	$ 22,955	$ 25,178	6	3.8	L4	23	8.6
2000	112	3591	205	$ 25,000	$ 24,355	$ 26,096	6	3.8	L4	23	8.9
2001	112	3567	205	$ 24,762	$ 24,477	$ 25,165	6	3.8	L4	23	8.9
2002	112	3567	205	$ 24,975	$ 24,975	$ 24,975	6	3.8	L4	23	8.9

Cadillac El Dorado – Luxury Car



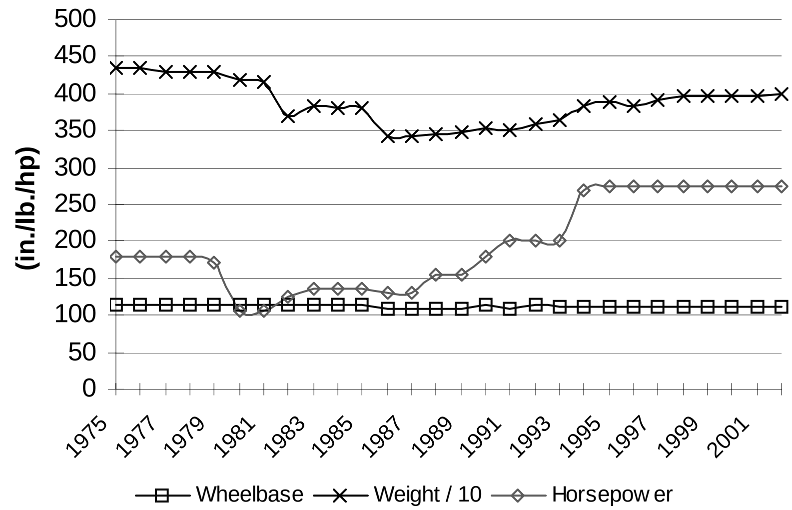


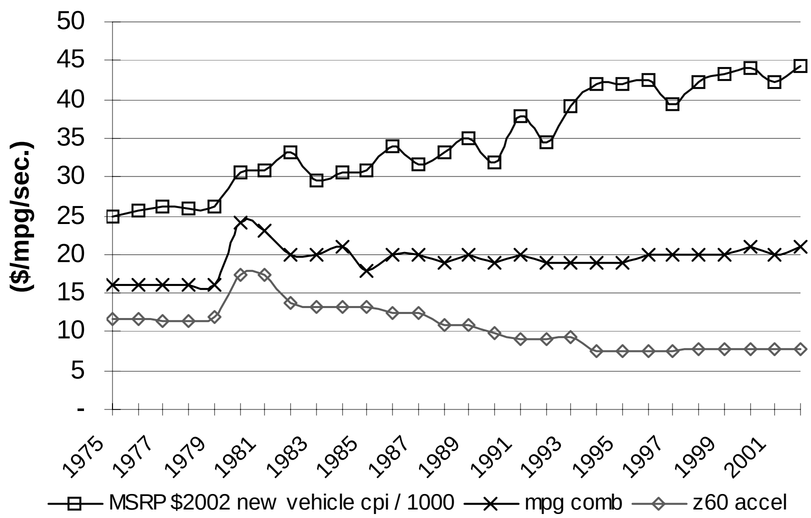


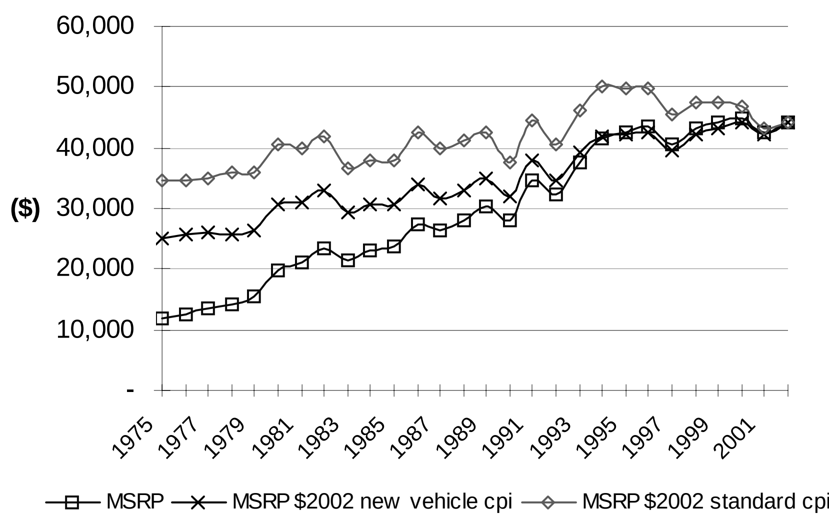
Cadillac El Dorado

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	126	5254	190	$ 9,948	$ 21,715	$ 29,345	8	.	.	11	12.9
1976	126	5231	190	$ 10,586	$ 21,726	$ 29,487	8	.	.	11	12.9
1977	126	5101	180	$ 11,187	$ 21,818	$ 29,285	8	.	.	11	13.2
1978	126	5100	180	$ 11,921	$ 21,593	$ 29,952	8	7	A	11	13.2
1979	114	3900	125	$ 14,955	$ 25,102	$ 34,300	8	5.7	A3	24	14.2
1980	114	4080	105	$ 13,800	$ 19,984	$ 28,512	8	5.7	A3	24	17.0
1981	114	3930	140	$ 16,492	$ 24,166	$ 31,176	8	6	A3	18	13.1
1982	114	3625	125	$ 18,716	$ 26,383	$ 33,362	8	4.1	A4	20	13.4
1983	114	3748	135	$ 19,334	$ 26,572	$ 33,106	8	4.1	A4	20	13.0
1984	114	3734	135	$ 20,842	$ 27,837	$ 34,336	8	4.1	A4	21	12.9
1985	114	3734	135	$ 21,431	$ 27,733	$ 34,180	8	4.1	L4	18	12.9
1986	108	3365	130	$ 24,751	$ 30,726	$ 38,734	8	4.1	L4	20	12.2
1987	108	3360	130	$ 23,740	$ 28,442	$ 35,915	8	4.1	L4	20	12.2
1988	108	3398	155	$ 25,416	$ 29,851	$ 37,104	8	4.5	L4	19	10.7
1989	108	3421	155	$ 27,288	$ 31,432	$ 38,218	8	4.5	L4	20	10.8
1990	108	3426	180	$ 29,045	$ 32,958	$ 38,727	8	4.5	L4	19	9.6
1991	108	3469	200	$ 31,825	$ 34,873	$ 40,959	8	4.9	L4	20	8.9
1992	108	3604	200	$ 33,070	$ 35,362	$ 41,545	8	4.9	L4	19	9.2
1993	108	3840	270	$ 34,490	$ 36,011	$ 42,267	8	4.6	L4	19	7.5
1994	108	3774	270	$ 37,915	$ 38,277	$ 45,516	8	4.6	L4	19	7.5
1995	108	3774	275	$ 38,855	$ 38,380	$ 45,551	8	4.6	L4	19	7.4
1996	108	3765	275	$ 41,135	$ 39,942	$ 46,958	8	4.6	L4	20	7.3
1997	108	3821	275	$ 38,660	$ 37,460	$ 43,196	8	4.6	L4	20	7.4
1998	108	3843	275	$ 39,160	$ 38,214	$ 43,128	8	4.6	L4	20	7.5
1999	108	3843	275	$ 39,905	$ 39,248	$ 43,047	8	4.6	L4	20	7.5
2000	108	3843	275	$ 39,815	$ 39,159	$ 41,561	8	4.6	L4	21	7.5
2001	108	3814	275	$ 40,756	$ 40,287	$ 41,419	8	4.6	L4	20	7.4
2002	108	3814	275	$ 42,610	$ 42,610	$ 42,610	8	4.6	L4	21	7.4

Cadillac Seville – Luxury Car



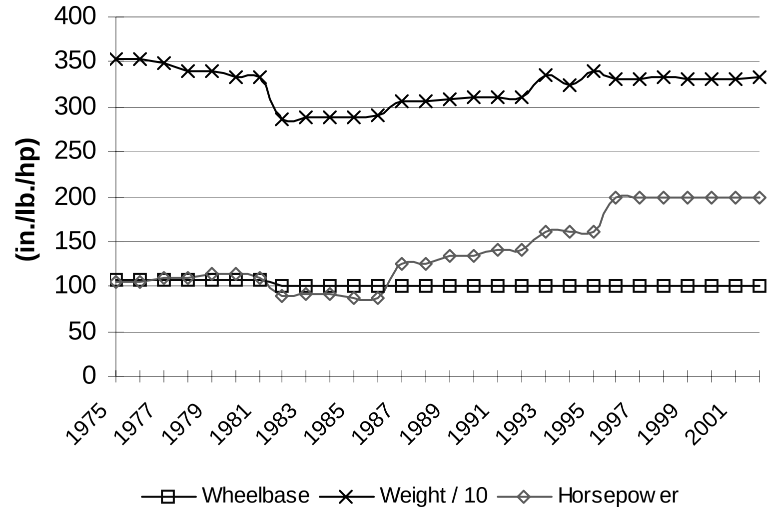


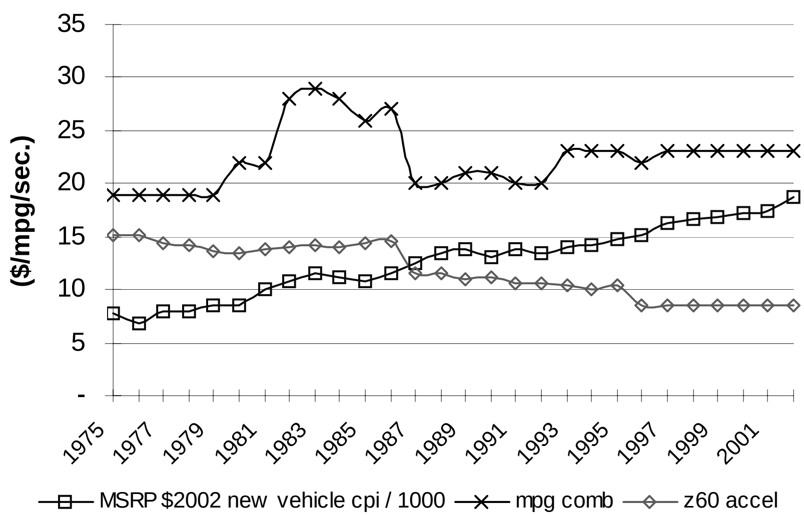


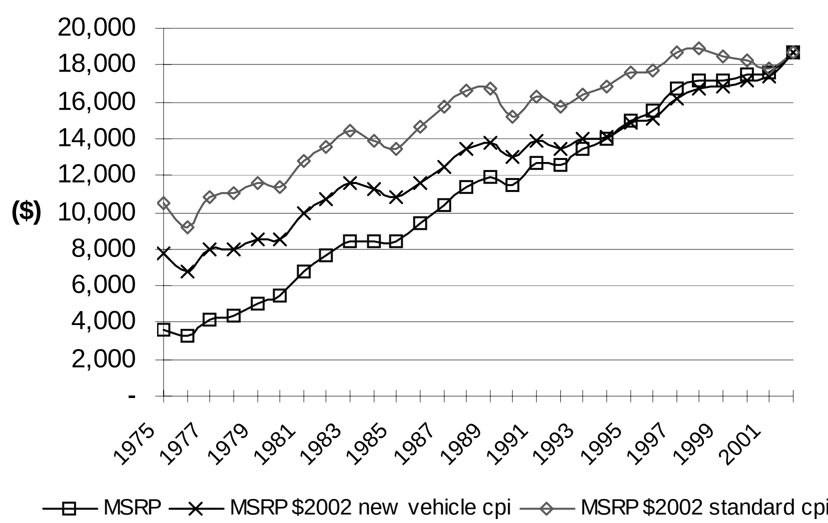
Cadillac Seville

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	114	4341	180	$ 11,788	$ 24,898	$ 34,773	8	.	.	16	11.6
1976	114	4340	180	$ 12,479	$ 25,611	$ 34,760	8	.	.	16	11.6
1977	114	4300	180	$ 13,359	$ 26,054	$ 34,971	8	.	.	16	11.5
1978	114	4300	180	$ 14,267	$ 25,842	$ 35,847	8	5.7	A	16	11.5
1979	114	4290	170	$ 15,646	$ 26,262	$ 35,885	8	5.7	A3	16	12.0
1980	114	4185	105	$ 19,662	$ 30,538	$ 40,624	8	5.7	A3	24	17.3
1981	114	4167	105	$ 21,088	$ 30,901	$ 39,864	8	5.7	A3	23	17.3
1982	114	3706	125	$ 23,433	$ 33,032	$ 41,770	8	4.1	A4	20	13.7
1983	114	3844	135	$ 21,440	$ 29,467	$ 36,712	8	4.1	A4	20	13.2
1984	114	3804	135	$ 22,962	$ 30,668	$ 37,829	8	4.1	A4	21	13.1
1985	114	3803	135	$ 23,759	$ 30,746	$ 37,893	8	4.1	L4	18	13.1
1986	108	3428	130	$ 27,256	$ 33,836	$ 42,654	8	4.1	L4	20	12.4
1987	108	3419	130	$ 26,326	$ 31,541	$ 39,828	8	4.1	L4	20	12.4
1988	108	3449	155	$ 28,152	$ 33,065	$ 41,098	8	4.5	L4	19	10.8
1989	108	3469	155	$ 30,300	$ 34,901	$ 42,437	8	4.5	L4	20	10.9
1990	114	3543	180	$ 28,090	$ 31,874	$ 37,453	8	4.5	L4	19	9.8
1991	114	3512	200	$ 34,545	$ 37,853	$ 44,459	8	4.9	L4	20	9.0
1992	114	3591	200	$ 32,340	$ 34,582	$ 40,628	8	4.9	L4	19	9.1
1993	111	3648	200	$ 37,590	$ 39,248	$ 46,066	8	4.6	L4	19	9.2
1994	111	3830	270	$ 41,615	$ 42,013	$ 49,958	8	4.6	L4	19	7.5
1995	111	3892	275	$ 42,570	$ 42,049	$ 49,906	8	4.6	L4	19	7.5
1996	111	3832	275	$ 43,635	$ 42,370	$ 49,812	8	4.6	L4	20	7.4
1997	111	3900	275	$ 40,660	$ 39,397	$ 45,430	8	4.6	L4	20	7.5
1998	112	3972	275	$ 43,160	$ 42,117	$ 47,533	8	4.6	L4	20	7.7
1999	112	3970	275	$ 44,025	$ 43,300	$ 47,492	8	4.6	L4	20	7.7
2000	112	3970	275	$ 44,775	$ 44,037	$ 46,738	8	4.6	L4	21	7.7
2001	112	3970	275	$ 42,655	$ 42,164	$ 43,349	8	4.6	L4	20	7.7
2002	112	3992	275	$ 44,269	$ 44,269	$ 44,269	8	4.6	L4	21	7.7

Chevrolet Camaro – Sports Car



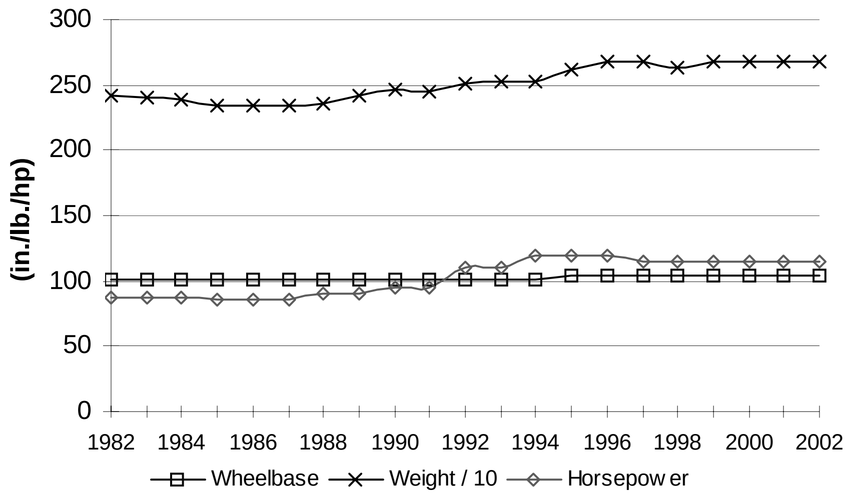


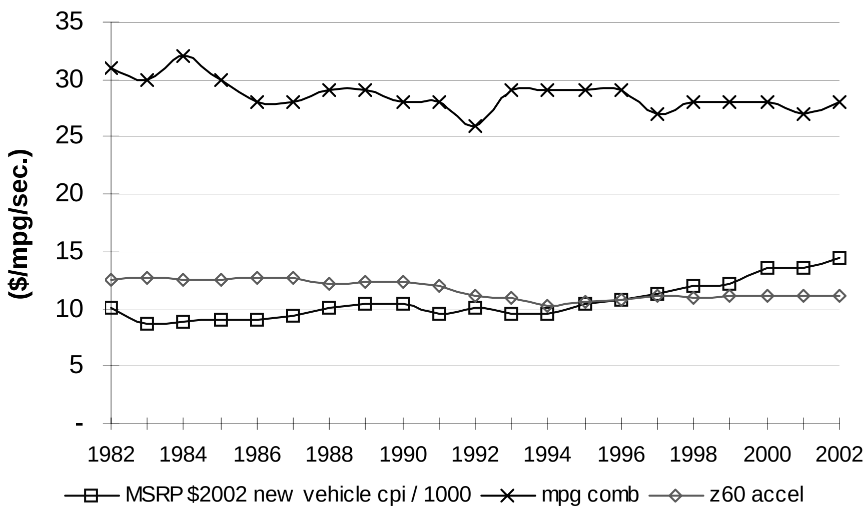


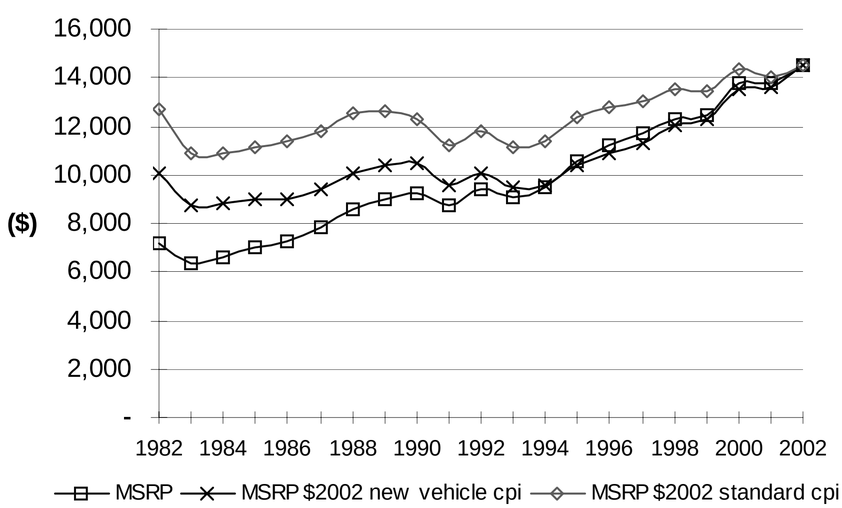
Chevrolet Camaro

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	108	3531	105	$ 3,553	$ 7,756	$ 10,481	6	.	.	19	15.1
1976	108	3531	105	$ 3,283	$ 6,738	$ 9,145	6	.	.	19	15.1
1977	108	3479	110	$ 4,113	$ 8,022	$ 10,767	6	.	.	19	14.4
1978	108	3403	110	$ 4,414	$ 7,995	$ 11,090	6	4.1	A	19	14.1
1979	108	3392	115	$ 5,073	$ 8,515	$ 11,635	6	4.1	A3	19	13.6
1980	108	3328	115	$ 5,499	$ 8,541	$ 11,362	6	3.8	A3	22	13.4
1981	108	3330	110	$ 6,780	$ 9,935	$ 12,817	6	3.8	A3	22	13.9
1982	101	2850	90	$ 7,630	$ 10,756	$ 13,601	4	2.5	M4	28	14.1
1983	101	2883	92	$ 8,450	$ 11,613	$ 14,469	4	2.5	A4	29	14.3
1984	101	2892	92	$ 8,409	$ 11,231	$ 13,853	4	2.5	M4	28	14.0
1985	101	2881	88	$ 8,399	$ 10,869	$ 13,396	4	2.5	M5	26	14.4
1986	101	2900	88	$ 9,349	$ 11,606	$ 14,631	4	2.5	M5	27	14.5
1987	101	3062	125	$ 10,409	$ 12,471	$ 15,747	6	2.8	M5	20	11.5
1988	101	3055	125	$ 11,409	$ 13,400	$ 16,655	6	2.8	M5	20	11.5
1989	101	3082	135	$ 11,934	$ 13,746	$ 16,714	6	2.8	M5	21	10.9
1990	101	3107	135	$ 11,434	$ 12,974	$ 15,245	6	3.1	L4	21	11.1
1991	101	3103	140	$ 12,649	$ 13,860	$ 16,279	6	3.1	M5	20	10.7
1992	101	3103	140	$ 12,565	$ 13,436	$ 15,785	6	3.1	M5	20	10.7
1993	101	3355	160	$ 13,399	$ 13,990	$ 16,420	6	3.3	L4	23	10.3
1994	101	3247	160	$ 13,989	$ 14,123	$ 16,794	6	3.3	L4	23	10.1
1995	101	3390	160	$ 14,995	$ 14,812	$ 17,579	6	3.3	L4	23	10.4
1996	101	3306	200	$ 15,495	$ 15,046	$ 17,688	6	3.8	L4	22	8.5
1997	101	3307	200	$ 16,740	$ 16,220	$ 18,704	6	3.8	M5	23	8.5
1998	101	3331	200	$ 17,150	$ 16,736	$ 18,888	6	3.8	M5	23	8.6
1999	101	3306	200	$ 17,160	$ 16,877	$ 18,511	6	3.8	M5	23	8.5
2000	101	3306	200	$ 17,490	$ 17,202	$ 18,257	6	3.8	M5	23	8.5
2001	101	3306	200	$ 17,560	$ 17,358	$ 17,846	6	3.8	L4	23	8.5
2002	101	3323	200	$ 18,655	$ 18,655	$ 18,655	6	3.8	M5	23	8.5

Chevrolet Cavalier – Compact Car



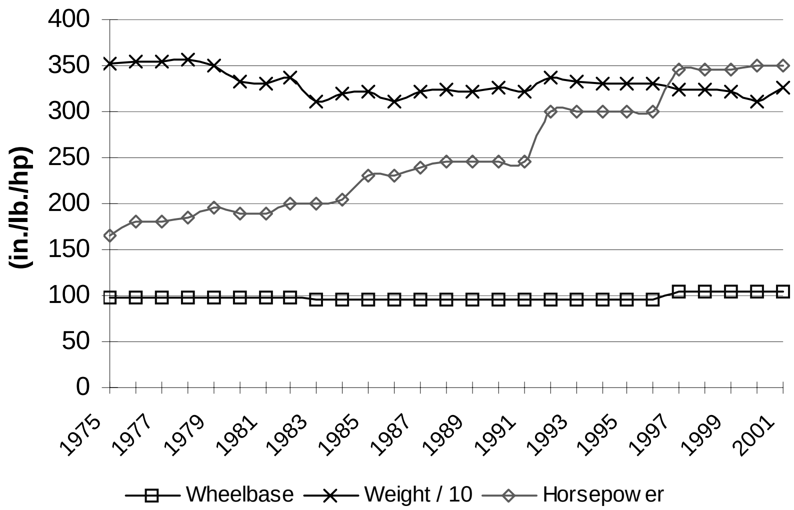


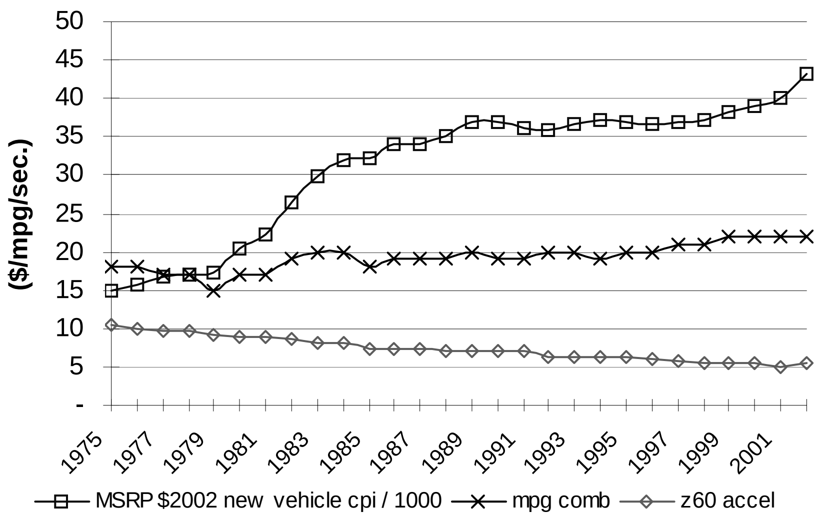


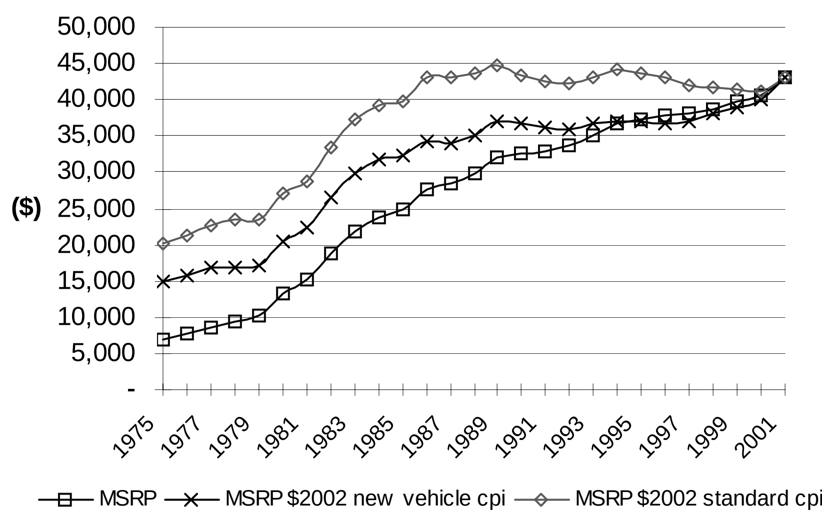
Chevrolet Cavalier

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1982	101	2413	88	$ 7,137	$ 10,061	$ 12,722	4	1.8	M4	31	12.6
1983	101	2403	88	$ 6,369	$ 8,753	$ 10,906	4	2	A3	30	12.8
1984	101	2389	88	$ 6,592	$ 8,804	$ 10,860	4	2	M4	32	12.5
1985	101	2339	85	$ 6,976	$ 9,027	$ 11,126	4	2	M4	30	12.6
1986	101	2342	85	$ 7,258	$ 9,010	$ 11,358	4	2	M4	28	12.6
1987	101	2345	85	$ 7,819	$ 9,368	$ 11,829	4	2	M4	28	12.7
1988	101	2363	90	$ 8,595	$ 10,095	$ 12,547	4	2	M5	29	12.2
1989	101	2423	90	$ 9,020	$ 10,390	$ 12,633	4	2	M5	29	12.4
1990	101	2471	95	$ 9,245	$ 10,490	$ 12,327	4	2.2	L3	28	12.3
1991	101	2444	95	$ 8,725	$ 9,561	$ 11,229	4	2.2	M5	28	12.0
1992	101	2509	110	$ 9,374	$ 10,024	$ 11,776	4	2.2	L3	26	11.1
1993	101	2520	110	$ 9,095	$ 9,496	$ 11,146	4	2.2	M5	29	11.0
1994	101	2520	120	$ 9,470	$ 9,561	$ 11,369	4	2.2	M5	29	10.2
1995	104	2617	120	$ 10,545	$ 10,416	$ 12,362	4	2.2	M5	29	10.5
1996	104	2676	120	$ 11,195	$ 10,870	$ 12,780	4	2.2	M5	29	10.7
1997	104	2676	115	$ 11,680	$ 11,317	$ 13,050	4	2.2	M5	27	11.1
1998	104	2630	115	$ 12,310	$ 12,013	$ 13,557	4	2.2	M5	28	10.9
1999	104	2676	115	$ 12,481	$ 12,275	$ 13,464	4	2.2	M5	28	11.1
2000	104	2676	115	$ 13,770	$ 13,543	$ 14,374	4	2.2	M5	28	11.1
2001	104	2676	115	$ 13,780	$ 13,621	$ 14,004	4	2.2	M5	27	11.1
2002	104	2676	115	$ 14,500	$ 14,500	$ 14,500	4	2.2	M5	28	11.1

Chevrolet Corvette – Sports/Luxury Car



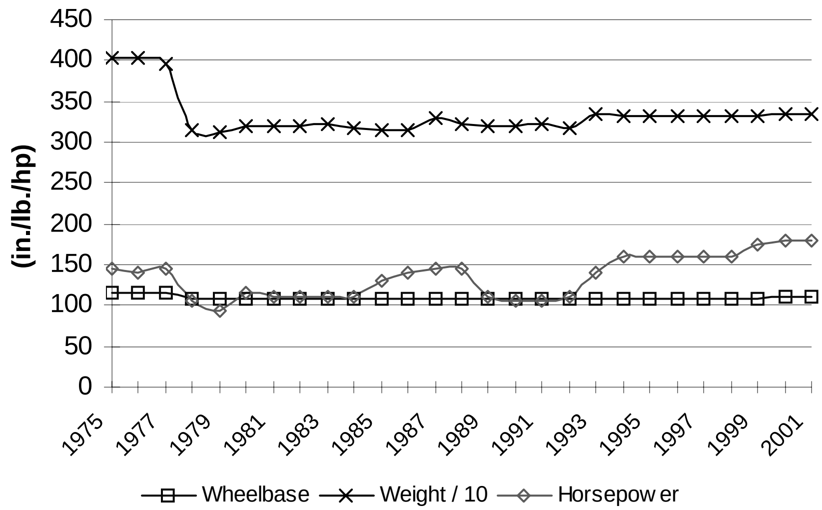


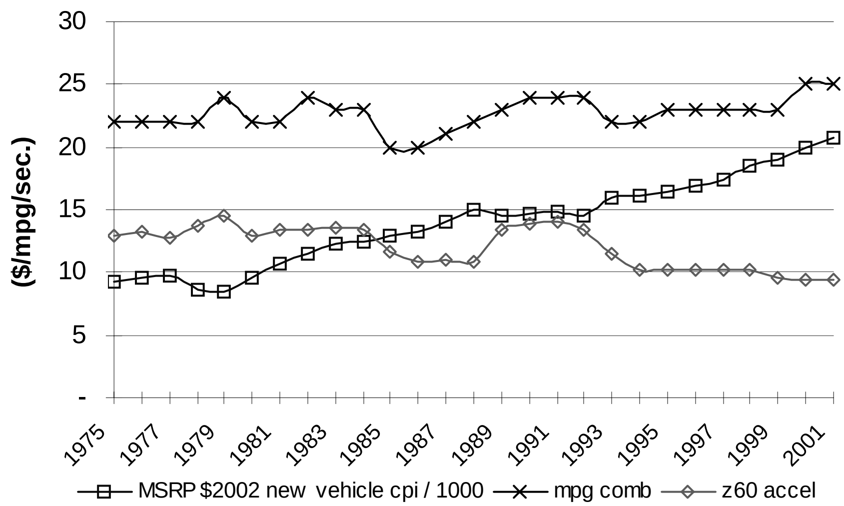


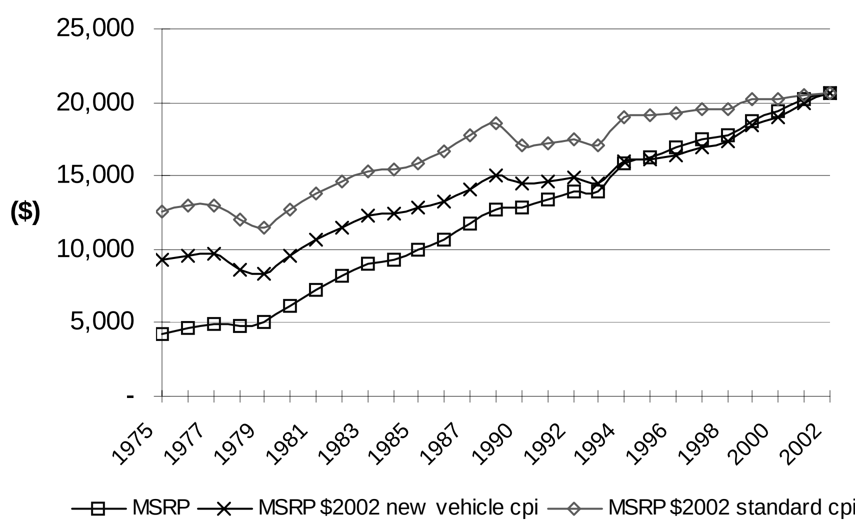
Chevrolet Corvette

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	98	3529	165	$ 6,810	$ 14,865	$ 20,088	8	.	.	18	10.5
1976	98	3541	180	$ 7,605	$ 15,608	$ 21,184	8	.	.	18	9.8
1977	98	3534	180	$ 8,647	$ 16,864	$ 22,636	8	.	.	17	9.8
1978	98	3572	185	$ 9,352	$ 16,940	$ 23,497	8	5.7	A	17	9.7
1979	98	3503	195	$ 10,220	$ 17,154	$ 23,440	8	5.7	M4	15	9.1
1980	98	3334	190	$ 13,140	$ 20,409	$ 27,149	8	5.7	A3	17	9.0
1981	98	3307	190	$ 15,248	$ 22,343	$ 28,824	8	5.7	A3	17	8.9
1982	98	3367	200	$ 18,750	$ 26,431	$ 33,422	8	5.7	A4	19	8.7
1983	96	3117	200	$ 21,800	$ 29,961	$ 37,329	8	5.7	A4	20	8.1
1984	96	3192	205	$ 23,835	$ 31,834	$ 39,267	8	5.7	M4	20	8.1
1985	96	3216	230	$ 24,878	$ 32,194	$ 39,678	8	5.7	L4	18	7.5
1986	96	3101	230	$ 27,502	$ 34,141	$ 43,039	8	5.7	M4	19	7.3
1987	96	3216	240	$ 28,474	$ 34,114	$ 43,077	8	5.7	L4	19	7.2
1988	96	3229	245	$ 29,955	$ 35,182	$ 43,730	8	5.7	M4	19	7.1
1989	96	3223	245	$ 32,045	$ 36,911	$ 44,881	8	5.7	L4	20	7.1
1990	96	3255	245	$ 32,479	$ 36,854	$ 43,305	8	5.7	M6	19	7.2
1991	96	3223	245	$ 32,985	$ 36,144	$ 42,452	8	5.7	L4	19	7.1
1992	96	3380	300	$ 33,635	$ 35,966	$ 42,255	8	5.7	M6	20	6.3
1993	96	3333	300	$ 35,145	$ 36,695	$ 43,070	8	5.7	M6	20	6.3
1994	96	3309	300	$ 36,735	$ 37,086	$ 44,100	8	5.7	L4	19	6.2
1995	96	3309	300	$ 37,345	$ 36,888	$ 43,781	8	5.7	M6	20	6.2
1996	96	3298	300	$ 37,790	$ 36,694	$ 43,139	8	5.7	M6	20	6.1
1998	105	3245	345	$ 38,060	$ 37,140	$ 41,916	8	5.7	M6	21	5.5
1999	105	3245	345	$ 38,777	$ 38,138	$ 41,831	8	5.7	M6	22	5.5
2000	105	3221	345	$ 39,730	$ 39,075	$ 41,472	8	5.7	M6	22	5.5
2001	105	3115	350	$ 40,475	$ 40,009	$ 41,133	8	5.7	M6	22	5.5
2002	105	3255	350	$ 43,225	$ 43,225	$ 43,225	8	5.7	M6	22	5.5

Chevrolet Monte Carlo/Lumina – Midsize Car



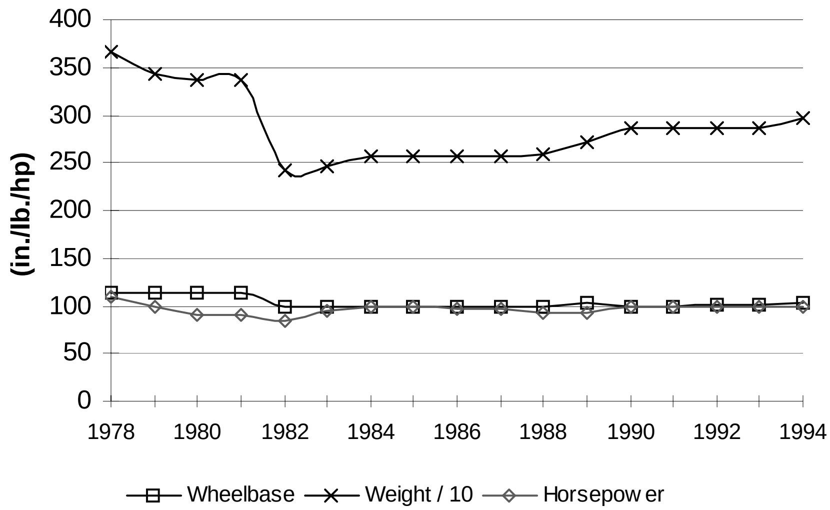


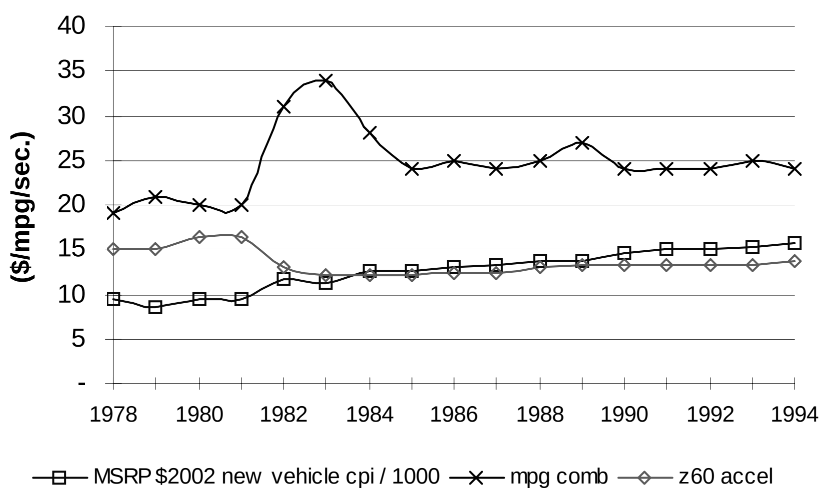


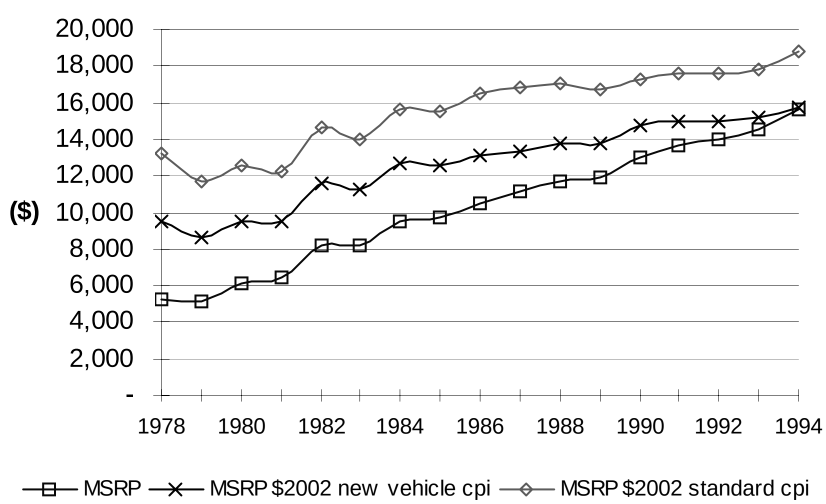
Chevrolet Monte Carlo/Lumina

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	108	3531	105	$ 3,553	$ 7,756	$ 10,481	6	.	.	19	15.1
1976	108	3531	105	$ 3,283	$ 6,738	$ 9,145	6	.	.	19	15.1
1977	108	3479	110	$ 4,113	$ 8,022	$ 10,767	6	.	.	19	14.4
1978	108	3403	110	$ 4,414	$ 7,995	$ 11,090	6	4.1	A	19	14.1
1979	108	3392	115	$ 5,073	$ 8,515	$ 11,635	6	4.1	A3	19	13.6
1980	108	3328	115	$ 5,499	$ 8,541	$ 11,362	6	3.8	A3	22	13.4
1981	108	3330	110	$ 6,780	$ 9,935	$ 12,817	6	3.8	A3	22	13.9
1982	101	2850	90	$ 7,630	$ 10,756	$ 13,601	4	2.5	M4	28	14.1
1983	101	2883	92	$ 8,450	$ 11,613	$ 14,469	4	2.5	A4	29	14.3
1984	101	2892	92	$ 8,409	$ 11,231	$ 13,853	4	2.5	M4	28	14.0
1985	101	2881	88	$ 8,399	$ 10,869	$ 13,396	4	2.5	M5	26	14.4
1986	101	2900	88	$ 9,349	$ 11,606	$ 14,631	4	2.5	M5	27	14.5
1987	101	3062	125	$ 10,409	$ 12,471	$ 15,747	6	2.8	M5	20	11.5
1988	101	3055	125	$ 11,409	$ 13,400	$ 16,655	6	2.8	M5	20	11.5
1989	101	3082	135	$ 11,934	$ 13,746	$ 16,714	6	2.8	M5	21	10.9
1990	101	3107	135	$ 11,434	$ 12,974	$ 15,245	6	3.1	L4	21	11.1
1991	101	3103	140	$ 12,649	$ 13,860	$ 16,279	6	3.1	M5	20	10.7
1992	101	3103	140	$ 12,565	$ 13,436	$ 15,785	6	3.1	M5	20	10.7
1993	101	3355	160	$ 13,399	$ 13,990	$ 16,420	6	3.3	L4	23	10.3
1994	101	3247	160	$ 13,989	$ 14,123	$ 16,794	6	3.3	L4	23	10.1
1995	101	3390	160	$ 14,995	$ 14,812	$ 17,579	6	3.3	L4	23	10.4
1996	101	3306	200	$ 15,495	$ 15,046	$ 17,688	6	3.8	L4	22	8.5
1997	101	3307	200	$ 16,740	$ 16,220	$ 18,704	6	3.8	M5	23	8.5
1998	101	3331	200	$ 17,150	$ 16,736	$ 18,888	6	3.8	M5	23	8.6
1999	101	3306	200	$ 17,160	$ 16,877	$ 18,511	6	3.8	M5	23	8.5
2000	101	3306	200	$ 17,490	$ 17,202	$ 18,257	6	3.8	M5	23	8.5
2001	101	3306	200	$ 17,560	$ 17,358	$ 17,846	6	3.8	L4	23	8.5
2002	101	3323	200	$ 18,655	$ 18,655	$ 18,655	6	3.8	M5	23	8.5

Chrysler LeBaron – Midsize Car



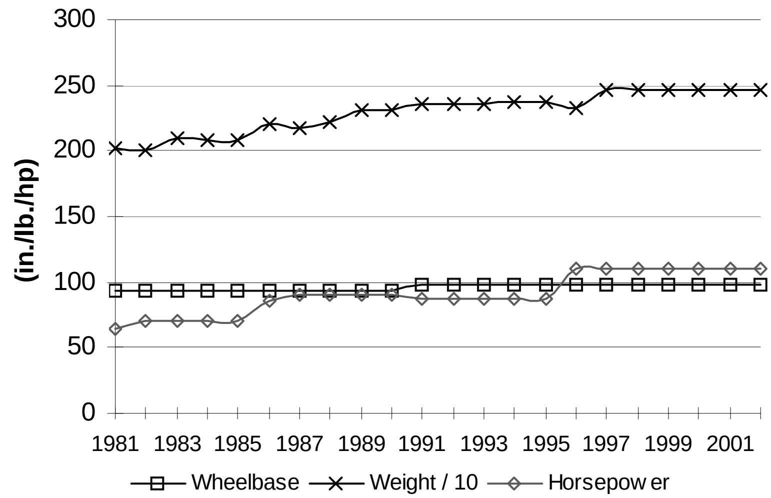


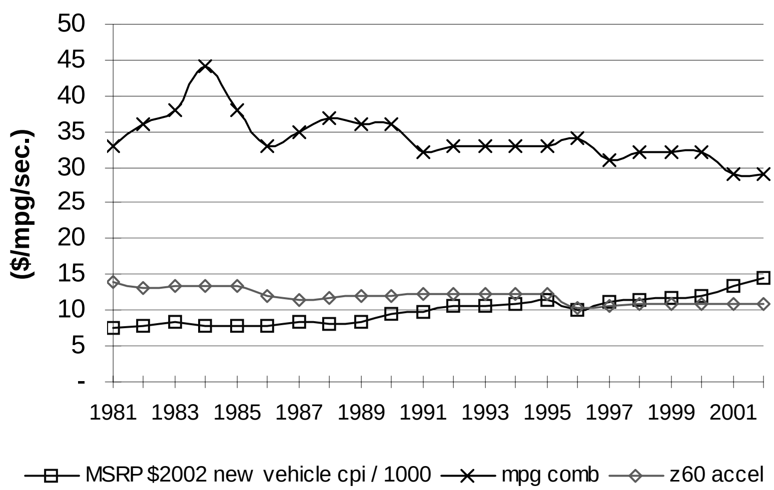


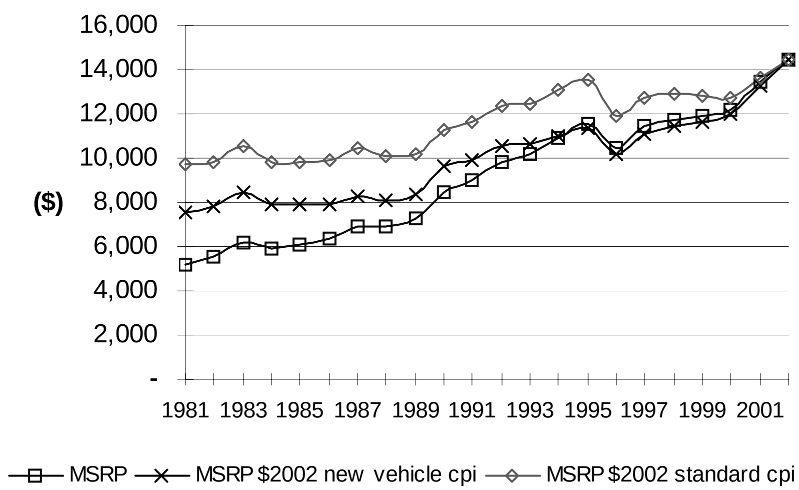
Chrysler LeBaron

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1978	113	3654	110	$ 5,270	$ 9,546	$ 13,241	6	3.7	A	19	15.0
1979	113	3429	100	$ 5,122	$ 8,597	$ 11,748	6	3.7	M4	21	15.0
1980	113	3375	90	$ 6,103	$ 9,479	$ 12,610	6	3.7	A3	20	16.5
1981	113	3375	90	$ 6,495	$ 9,517	$ 12,278	6	3.7	A3	20	16.5
1982	100	2416	84	$ 8,237	$ 11,611	$ 14,683	4	2.2	M4	31	13.1
1983	100	2464	94	$ 8,154	$ 11,207	$ 13,962	4	2.2	M5	34	12.2
1984	100	2560	99	$ 9,465	$ 12,641	$ 15,593	4	2.2	A3	28	12.2
1985	100	2559	99	$ 9,707	$ 12,561	$ 15,482	4	2.2	A3	24	12.2
1986	100	2566	97	$ 10,525	$ 13,066	$ 16,471	4	2.2	A3	25	12.5
1987	100	2566	97	$ 11,105	$ 13,305	$ 16,800	4	2.2	A3	24	12.5
1988	100	2592	93	$ 11,715	$ 13,759	$ 17,102	4	2.2	L3	25	13.0
1989	103	2714	93	$ 11,945	$ 13,759	$ 16,730	4	2.5	M5	27	13.2
1990	100	2863	100	$ 12,960	$ 14,706	$ 17,280	4	2.5	L3	24	13.3
1991	100	2853	100	$ 13,650	$ 14,957	$ 17,568	4	2.5	L3	24	13.2
1992	101	2863	100	$ 13,998	$ 14,968	$ 17,585	4	2.5	L3	24	13.3
1993	101	2863	100	$ 14,554	$ 15,196	$ 17,836	4	2.5	L3	25	13.3
1994	104	2971	100	$ 15,626	$ 15,775	$ 18,759	4	2.5	L3	24	13.7

Ford Escort – Compact Car



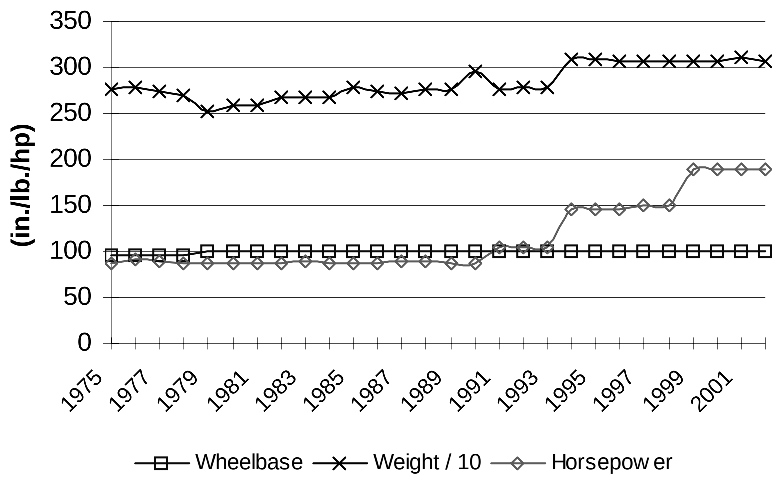


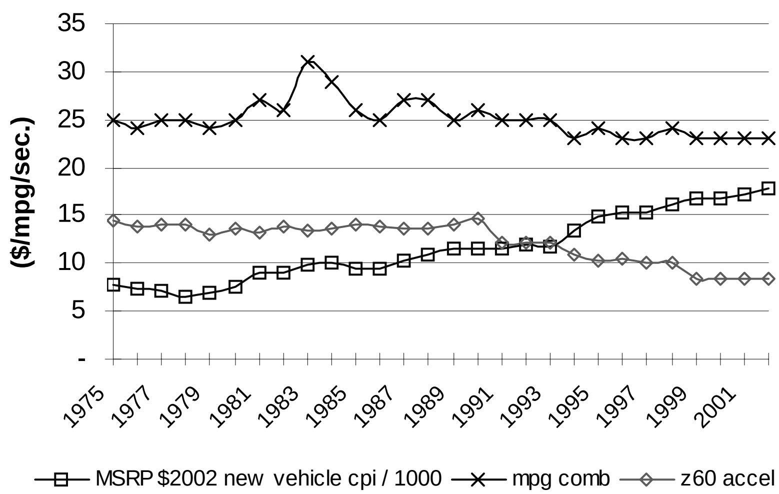


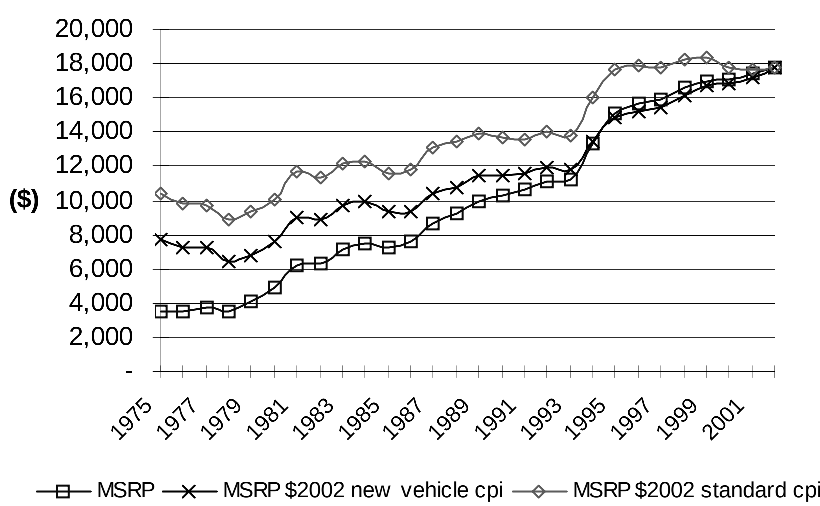
Ford Escort

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1981	94	2021	65	$ 5,158	$ 7,558	$ 9,750	4	1.6	M4	33	13.9
1982	94	2007	70	$ 5,518	$ 7,778	$ 9,836	4	1.6	M4	36	13.0
1983	94	2094	70	$ 6,154	$ 8,458	$ 10,538	4	1.6	M4	38	13.5
1984	94	2080	70	$ 5,937	$ 7,929	$ 9,781	4	1.6	M4	44	13.4
1985	94	2074	70	$ 6,135	$ 7,939	$ 9,785	4	1.6	M4	38	13.4
1986	94	2201	86	$ 6,360	$ 7,895	$ 9,953	4	1.9	M4	33	11.9
1987	94	2180	90	$ 6,895	$ 8,261	$ 10,431	4	1.9	M4	35	11.4
1988	94	2222	90	$ 6,895	$ 8,098	$ 10,066	4	1.9	M4	37	11.6
1989	94	2313	90	$ 7,299	$ 8,407	$ 10,223	4	1.9	M4	36	12.0
1990	94	2310	90	$ 8,476	$ 9,618	$ 11,301	4	1.9	M4	36	12.0
1991	98	2355	88	$ 9,029	$ 9,894	$ 11,620	4	1.9	M5	32	12.4
1992	98	2355	88	$ 9,858	$ 10,541	$ 12,384	4	1.9	M5	33	12.4
1993	98	2360	88	$ 10,172	$ 10,621	$ 12,466	4	1.9	M5	33	12.4
1994	98	2371	88	$ 10,925	$ 11,029	$ 13,115	4	1.9	M5	33	12.4
1995	98	2371	88	$ 11,530	$ 11,389	$ 13,517	4	1.9	M5	33	12.4
1996	98	2323	110	$ 10,455	$ 10,152	$ 11,935	4	1.9	M5	34	10.3
1997	98	2457	110	$ 11,430	$ 11,075	$ 12,771	4	2	M5	31	10.7
1998	98	2468	110	$ 11,745	$ 11,461	$ 12,935	4	2	M5	32	10.8
1999	98	2468	110	$ 11,870	$ 11,674	$ 12,805	4	2	M5	32	10.8
2000	98	2468	110	$ 12,200	$ 11,999	$ 12,735	4	2	L4	32	10.8
2001	98	2468	110	$ 13,435	$ 13,280	$ 13,653	4	2	L4	29	10.9
2002	98	2468	110	$ 14,450	$ 14,450	$ 14,450	4	2	L4	29	10.9

Ford Mustang – Sports Car



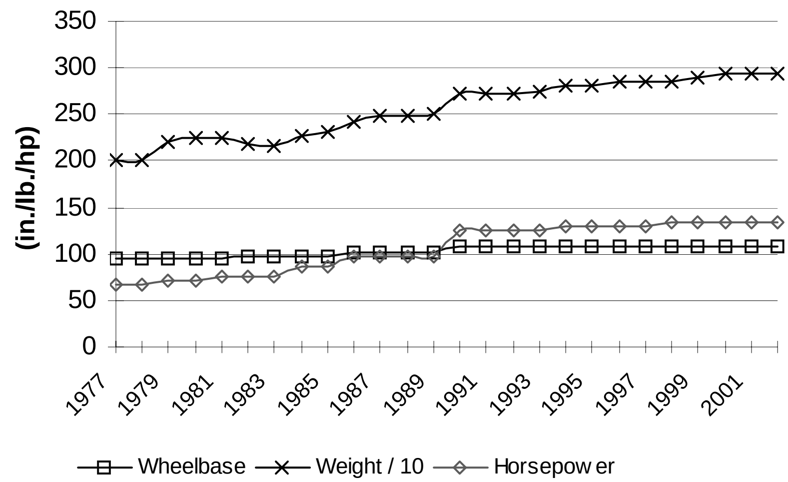


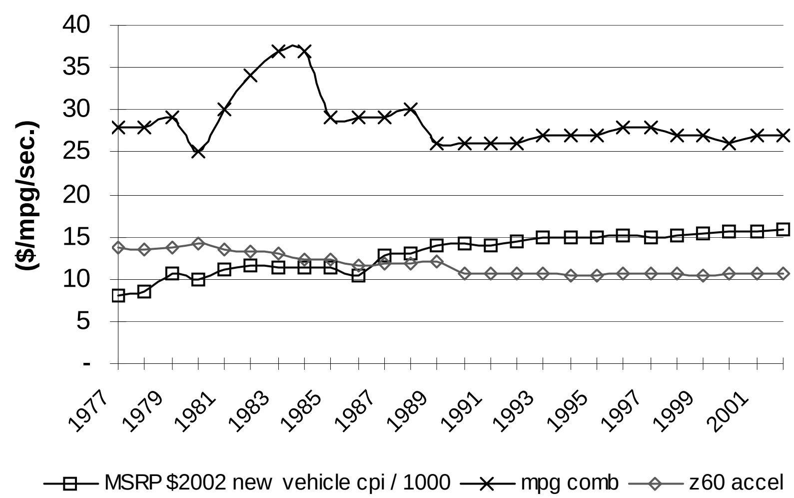


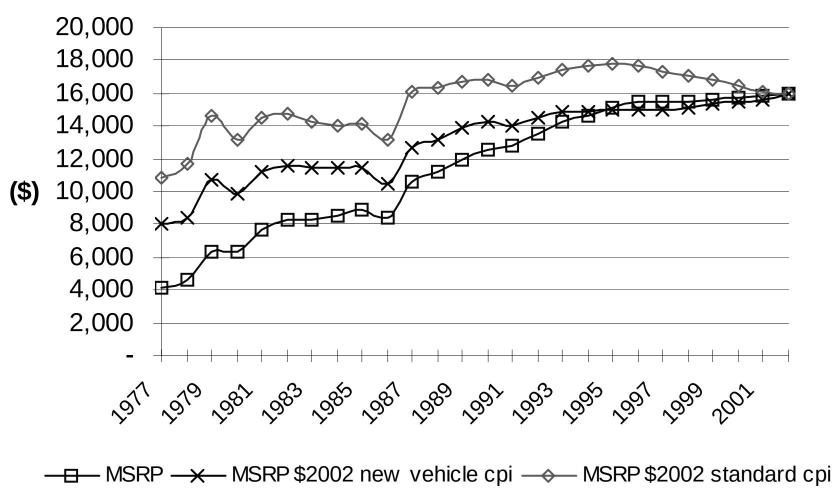
Ford Mustang

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	96	2759	87	$ 3,529	$ 7,703	$ 10,410	4	.	.	25	14.4
1976	96	2779	92	$ 3,525	$ 7,234	$ 9,819	4	.	.	24	13.9
1977	96	2735	89	$ 3,702	$ 7,220	$ 9,691	4	.	.	25	14.1
1978	96	2698	88	$ 3,555	$ 6,439	$ 8,932	4	2.3	A	25	14.0
1979	100	2532	88	$ 4,071	$ 6,833	$ 9,337	4	2.3	M4	24	13.1
1980	100	2588	88	$ 4,884	$ 7,586	$ 10,091	4	2.3	A3	25	13.6
1981	100	2588	88	$ 6,171	$ 9,042	$ 11,665	4	2.3	M4	27	13.3
1982	100	2683	86	$ 6,345	$ 8,944	$ 11,310	4	2.3	M4	26	13.9
1983	100	2679	90	$ 7,101	$ 9,759	$ 12,159	4	2.3	M4	31	13.4
1984	101	2664	88	$ 7,472	$ 9,980	$ 12,310	4	2.3	M4	29	13.6
1985	101	2782	88	$ 7,259	$ 9,394	$ 11,577	4	2.3	M4	26	14.1
1986	101	2733	88	$ 7,563	$ 9,389	$ 11,836	4	2.3	M4	25	13.9
1987	101	2724	90	$ 8,645	$ 10,357	$ 13,079	4	2.3	M5	27	13.6
1988	101	2751	90	$ 9,209	$ 10,816	$ 13,444	4	2.3	M5	27	13.7
1989	101	2754	88	$ 9,956	$ 11,468	$ 13,944	4	2.3	M5	25	14.0
1990	101	2960	88	$ 10,300	$ 11,520	$ 13,733	4	2.3	M5	26	14.8
1991	101	2759	105	$ 10,587	$ 11,601	$ 13,625	4	2.3	M5	25	12.2
1992	101	2775	105	$ 11,163	$ 11,937	$ 14,024	4	2.3	M5	25	12.2
1993	101	2775	105	$ 11,285	$ 11,783	$ 13,830	4	2.3	M5	25	12.2
1994	101	3077	145	$ 13,365	$ 13,493	$ 16,044	6	3.8	L4	23	11.0
1995	101	3077	145	$ 15,030	$ 14,846	$ 17,620	6	3.8	M5	24	10.3
1996	101	3065	145	$ 15,680	$ 15,225	$ 17,900	6	3.8	L4	23	10.4
1997	101	3065	150	$ 15,880	$ 15,387	$ 17,743	6	3.8	L4	23	10.1
1998	101	3065	150	$ 16,595	$ 16,194	$ 18,276	6	3.8	M5	24	10.0
1999	101	3069	190	$ 16,995	$ 16,715	$ 18,333	6	3.8	M5	23	8.4
2000	101	3069	190	$ 17,070	$ 16,789	$ 17,818	6	3.8	M5	23	8.4
2001	101	3114	190	$ 17,380	$ 17,180	$ 17,663	6	3.8	M5	23	8.5
2002	101	3066	190	$ 17,820	$ 17,820	$ 17,820	6	3.8	M5	23	8.4

Honda Accord – Compact/Midsize Car



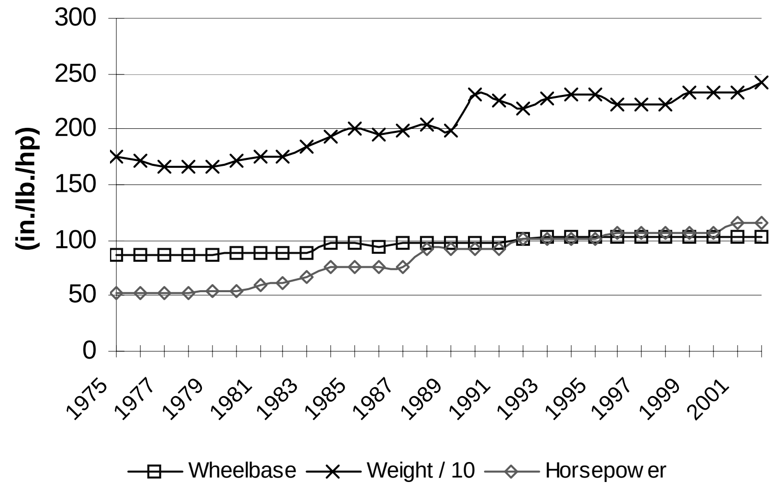


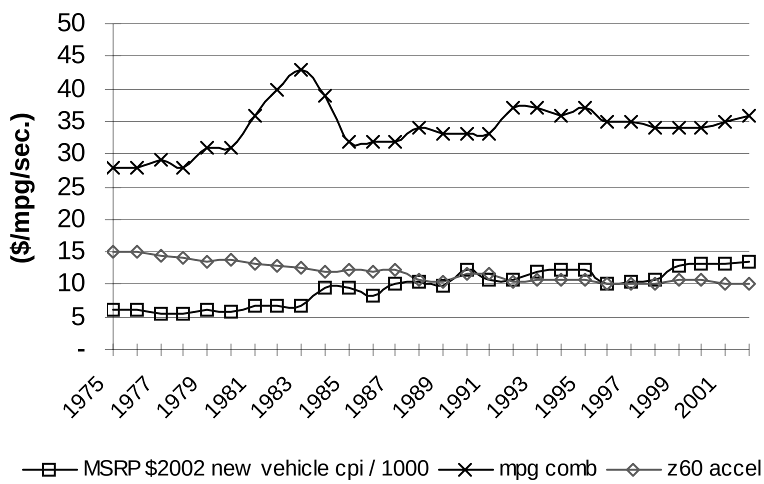


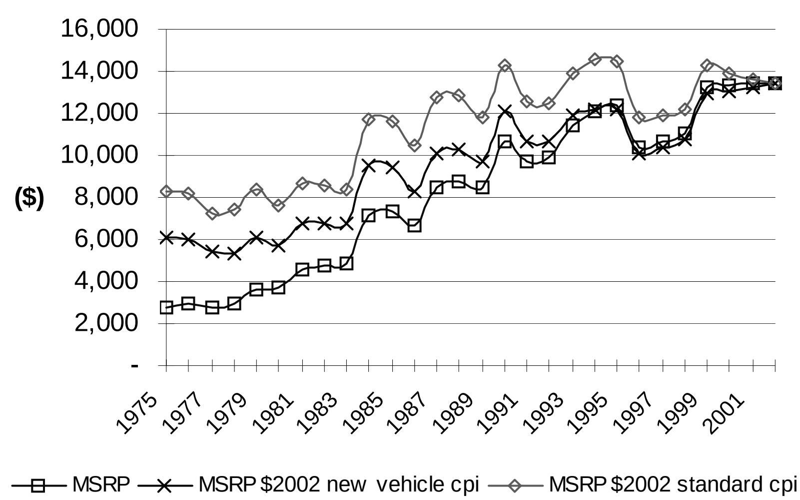
Honda Accord

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1977	94	2018	68	$ 4,145	$ 8,084	$ 10,851	4	1.6	M5	28	13.7
1978	94	2018	68	$ 4,645	$ 8,414	$ 11,671	4	1.6	M5	28	13.4
1979	94	2203	72	$ 6,365	$ 10,684	$ 14,599	4	1.8	M5	29	13.7
1980	94	2239	72	$ 6,365	$ 9,886	$ 13,151	4	1.8	A3	25	14.2
1981	94	2249	75	$ 7,645	$ 11,202	$ 14,452	4	1.8	M5	30	13.5
1982	97	2185	75	$ 8,245	$ 11,623	$ 14,697	4	1.8	M5	34	13.2
1983	97	2169	75	$ 8,345	$ 11,469	$ 14,289	4	1.8	M5	37	13.1
1984	97	2271	86	$ 8,549	$ 11,418	$ 14,084	4	1.8	M5	37	12.2
1985	97	2304	86	$ 8,845	$ 11,446	$ 14,107	4	1.8	M5	29	12.4
1986	102	2416	98	$ 8,429	$ 10,464	$ 13,191	4	2	M5	29	11.6
1987	102	2491	98	$ 10,625	$ 12,730	$ 16,074	4	2	M5	29	11.9
1988	102	2482	98	$ 11,175	$ 13,125	$ 16,314	4	2	M5	30	11.8
1989	102	2500	98	$ 11,910	$ 13,862	$ 16,681	4	2	L4	26	12.1
1990	107	2733	125	$ 12,590	$ 14,286	$ 16,787	4	2.2	M5	26	10.6
1991	107	2733	125	$ 12,805	$ 14,031	$ 16,480	4	2.2	M5	26	10.6
1992	107	2733	125	$ 13,515	$ 14,452	$ 16,979	4	2.2	M5	26	10.6
1993	107	2734	125	$ 14,280	$ 14,910	$ 17,500	4	2.2	M5	27	10.6
1994	107	2800	130	$ 14,680	$ 14,820	$ 17,623	4	2.2	M5	27	10.4
1995	107	2800	130	$ 15,180	$ 14,994	$ 17,796	4	2.2	M5	27	10.4
1996	107	2855	130	$ 15,480	$ 15,031	$ 17,671	4	2.2	M5	28	10.6
1997	107	2855	130	$ 15,495	$ 15,014	$ 17,313	4	2.2	M5	28	10.6
1998	107	2855	135	$ 15,495	$ 15,121	$ 17,065	4	2.3	M5	27	10.6
1999	107	2888	135	$ 15,615	$ 15,358	$ 16,845	4	2.3	M5	27	10.4
2000	107	2932	135	$ 15,785	$ 15,525	$ 16,477	4	2.3	M5	26	10.6
2001	107	2943	135	$ 15,840	$ 15,658	$ 16,098	4	2.3	M5	27	10.5
2002	107	2943	135	$ 15,940	$ 15,940	$ 15,940	4	2.3	M5	27	10.5

Honda Civic – Mini/Sub-Compact



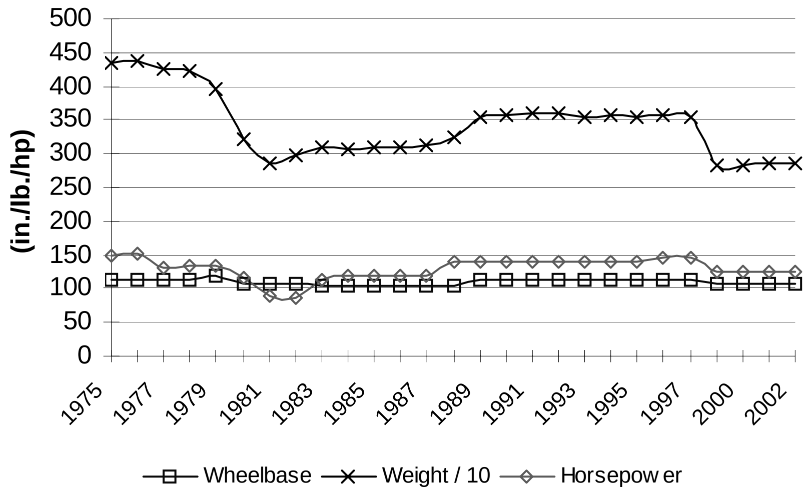


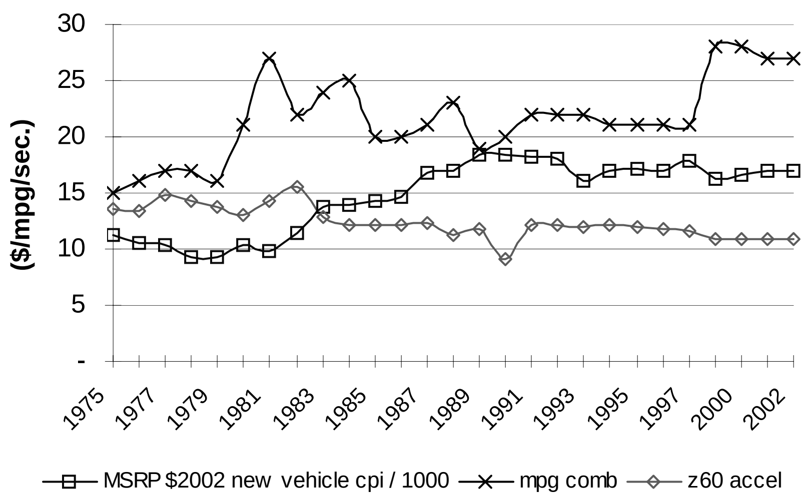


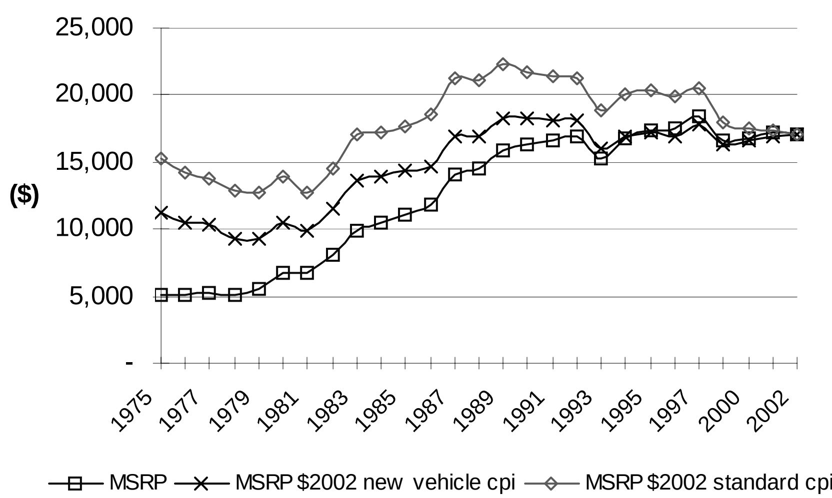
Honda Civic

Year	Wheel Base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	87	1748	53	$ 2,798	$ 6,108	$ 8,254	4	.	.	28	14.9
1976	87	1720	52	$ 2,939	$ 6,032	$ 8,187	4	.	.	28	14.9
1977	87	1665	52	$ 2,779	$ 5,420	$ 7,275	4	.	.	29	14.5
1978	87	1665	52	$ 2,969	$ 5,378	$ 7,460	4	1.2	M4	28	14.2
1979	87	1663	55	$ 3,649	$ 6,125	$ 8,369	4	1.2	M4	31	13.6
1980	89	1722	55	$ 3,699	$ 5,745	$ 7,643	4	1.3	M4	31	14.0
1981	89	1750	60	$ 4,599	$ 6,739	$ 8,694	4	1.3	M4	36	13.2
1982	89	1761	62	$ 4,799	$ 6,765	$ 8,554	4	1.3	M4	40	12.9
1983	89	1835	67	$ 4,899	$ 6,733	$ 8,389	4	1.3	M4	43	12.6
1984	97	1940	76	$ 7,099	$ 9,481	$ 11,695	4	1.5	M5	39	11.9
1985	97	2010	76	$ 7,295	$ 9,440	$ 11,635	4	1.5	M5	32	12.2
1986	94	1958	76	$ 6,699	$ 8,316	$ 10,484	4	1.5	M5	32	12.0
1987	97	1992	76	$ 8,455	$ 10,130	$ 12,791	4	1.5	M5	32	12.2
1988	98	2039	92	$ 8,795	$ 10,330	$ 12,839	4	1.5	M5	34	10.7
1989	98	1993	92	$ 8,445	$ 9,727	$ 11,828	4	1.5	M5	33	10.5
1990	98	2322	92	$ 10,695	$ 12,136	$ 14,260	4	1.5	M5	33	11.8
1991	98	2255	92	$ 9,750	$ 10,684	$ 12,548	4	1.5	M5	33	11.5
1992	101	2178	102	$ 9,940	$ 10,629	$ 12,487	4	1.5	M5	37	10.4
1993	103	2275	102	$ 11,385	$ 11,887	$ 13,952	4	1.5	M5	37	10.7
1994	103	2313	102	$ 12,100	$ 12,216	$ 14,526	4	1.5	M5	36	10.9
1995	103	2313	102	$ 12,360	$ 12,209	$ 14,490	4	1.5	M5	37	10.9
1996	103	2222	106	$ 10,360	$ 10,060	$ 11,826	4	1.6	M5	35	10.2
1997	103	2222	106	$ 10,650	$ 10,380	$ 11,899	4	1.6	M5	35	10.2
1998	103	2222	106	$ 11,045	$ 10,778	$ 12,164	4	1.6	M5	34	10.2
1999	103	2339	106	$ 13,200	$ 12,983	$ 14,239	4	1.6	M5	34	10.6
2000	103	2339	106	$ 13,300	$ 13,081	$ 13,883	4	1.6	M5	34	10.6
2001	103	2339	115	$ 13,400	$ 13,246	$ 13,618	4	1.7	M5	35	10.0
2002	103	2421	115	$ 13,450	$ 13,450	$ 13,450	4	1.7	M5	36	10.3

Mercury Cougar – Midsize/Compact Car



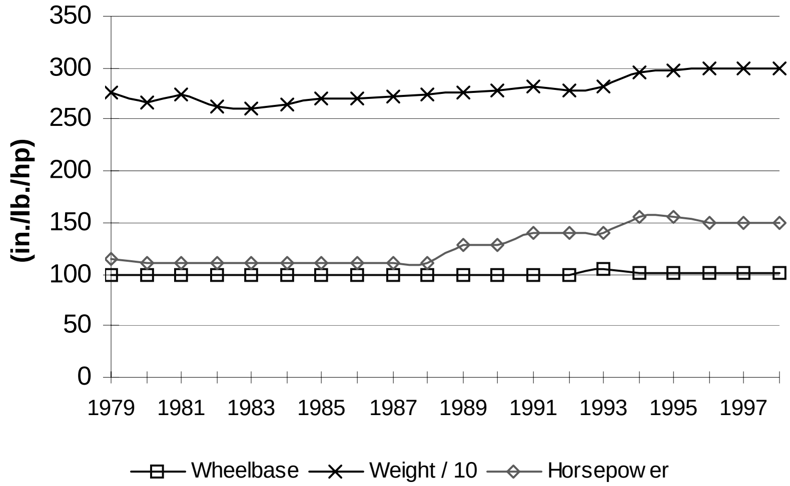


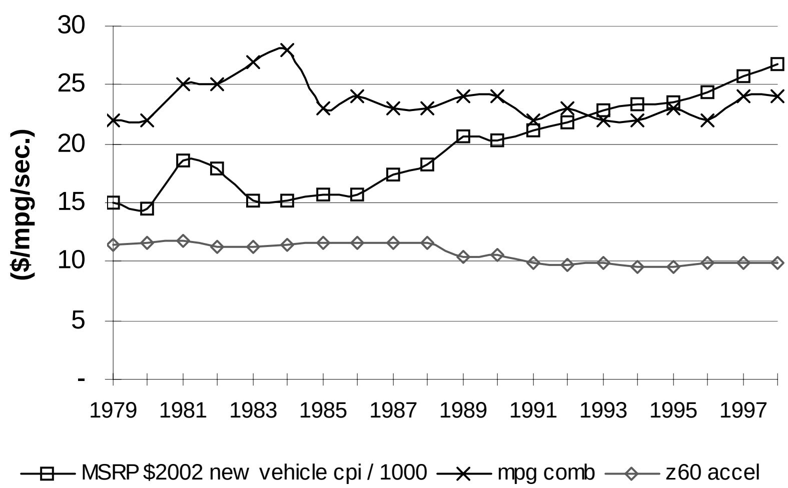


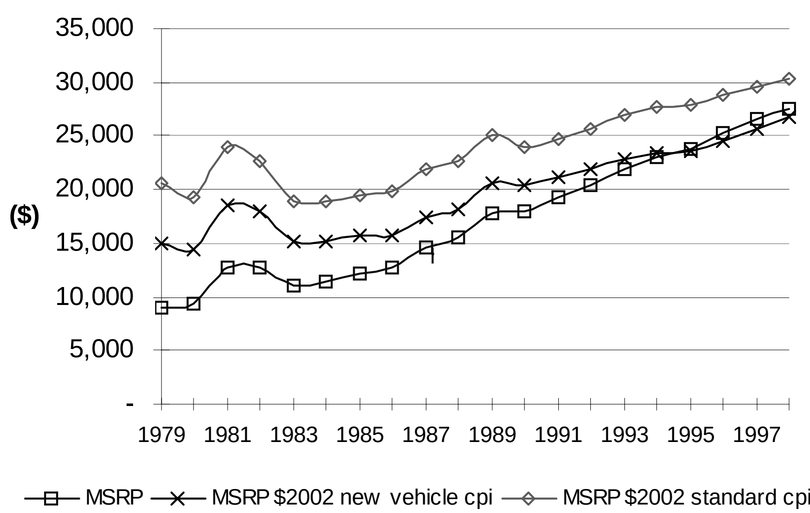
Mercury Cougar

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	114	4351	148	$ 5,153	$ 11,248	$ 15,201	8	.	.	15	13.6
1976	114	4376	152	$ 5,125	$ 10,518	$ 14,276	8	.	.	16	13.3
1977	114	4252	130	$ 5,274	$ 10,286	$ 13,806	8	.	.	17	14.8
1978	114	4231	134	$ 5,126	$ 9,285	$ 12,879	8	5	A	17	14.4
1979	118	3968	133	$ 5,524	$ 9,272	$ 12,670	8	5	A3	16	13.7
1980	108	3228	115	$ 6,719	$ 10,436	$ 13,882	8	4.2	A3	21	13.1
1981	106	2849	88	$ 6,694	$ 9,809	$ 12,654	4	2.3	M4	27	14.3
1982	106	2981	86	$ 8,158	$ 11,500	$ 14,542	6	3.8	A3	22	15.5
1983	104	3099	112	$ 9,953	$ 13,679	$ 17,043	6	3.8	A3	24	12.9
1984	104	3065	120	$ 10,410	$ 13,904	$ 17,150	6	3.8	A4	25	12.1
1985	104	3084	120	$ 11,082	$ 14,341	$ 17,675	6	3.8	L3	20	12.2
1986	104	3085	120	$ 11,853	$ 14,714	$ 18,549	6	3.8	L3	20	12.2
1987	104	3133	120	$ 14,062	$ 16,847	$ 21,274	6	3.8	L4	21	12.3
1988	104	3237	140	$ 14,458	$ 16,981	$ 21,107	6	3.8	L4	23	11.2
1989	113	3553	140	$ 15,905	$ 18,320	$ 22,276	6	3.8	M5	19	11.9
1990	113	3565	140	$ 16,255	$ 18,316	$ 21,673	6	3.8	M5	20	9.1
1991	113	3587	140	$ 16,579	$ 18,167	$ 21,337	6	3.8	L4	22	12.1
1992	113	3587	140	$ 16,880	$ 18,050	$ 21,206	6	3.8	L4	22	12.1
1993	113	3548	140	$ 15,340	$ 16,017	$ 18,799	6	3.8	L4	22	12.0
1994	113	3564	140	$ 16,755	$ 16,915	$ 20,114	6	3.8	L4	21	12.1
1995	113	3533	140	$ 17,370	$ 17,158	$ 20,363	6	3.8	L4	21	12.0
1996	113	3559	145	$ 17,490	$ 16,983	$ 19,966	6	3.8	L4	21	11.7
1997	113	3536	145	$ 18,340	$ 17,771	$ 20,492	6	3.8	L4	21	11.7
1999	107	2829	125	$ 16,595	$ 16,322	$ 17,902	4	2	M5	28	10.9
2000	107	2829	125	$ 16,820	$ 16,543	$ 17,557	4	2	M5	28	10.9
2001	106	2861	125	$ 17,150	$ 16,952	$ 17,429	4	2	M5	27	10.9
2002	106	2861	125	$ 16,995	$ 16,995	$ 16,995	4	2	M5	27	10.9

Saab 900 – Compact/Midsize Car



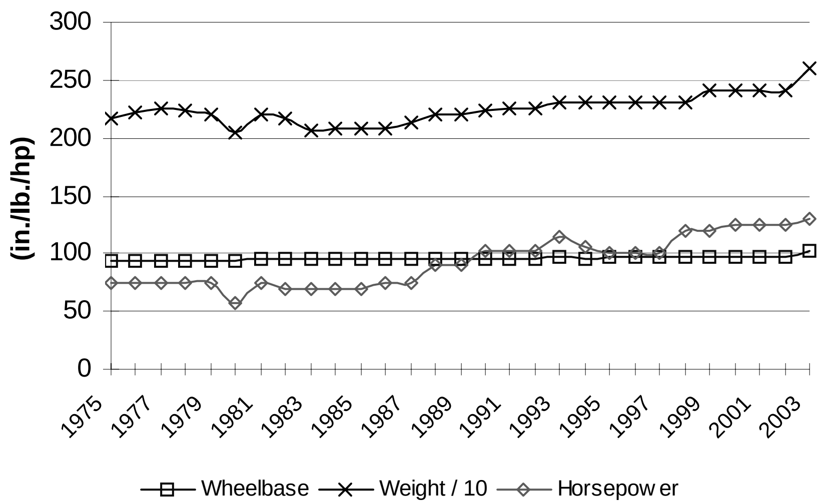


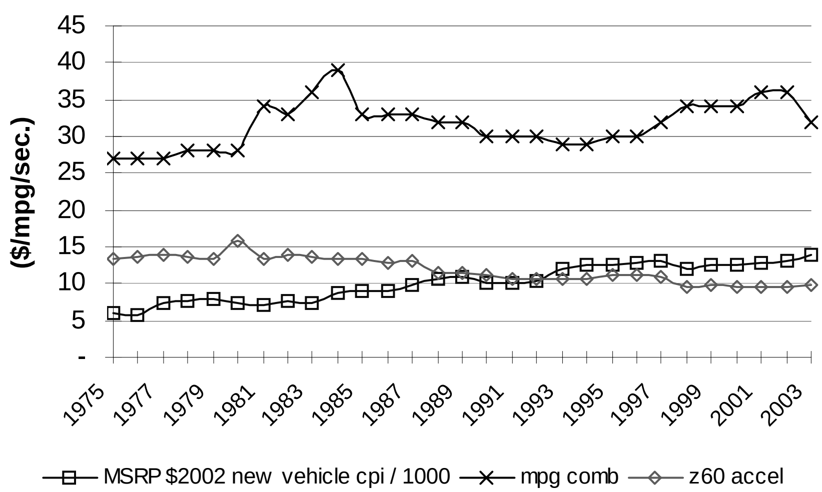


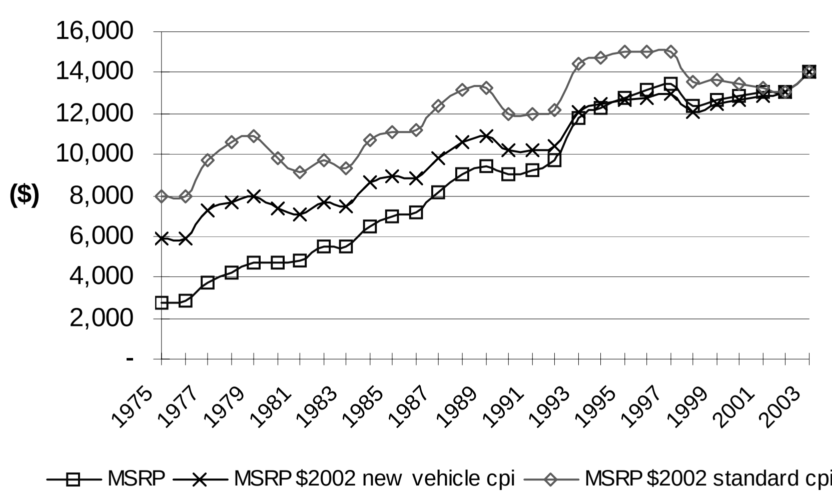
Saab 900

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1979	99	2760	115	$ 8,948	$ 15,019	$ 20,523	4	2	M4	22	11.4
1980	99	2660	110	$ 9,295	$ 14,437	$ 19,205	4	2	A3	22	11.6
1981	99	2740	110	$ 12,700	$ 18,609	$ 24,008	4	2	M5	25	11.7
1982	99	2630	110	$ 12,700	$ 17,903	$ 22,638	4	2	M5	25	11.3
1983	99	2600	110	$ 11,050	$ 15,187	$ 18,921	4	2	M5	27	11.2
1984	99	2640	110	$ 11,420	$ 15,253	$ 18,814	4	2	M5	28	11.4
1985	99	2695	110	$ 12,170	$ 15,749	$ 19,410	4	2	M5	23	11.5
1986	99	2706	110	$ 12,685	$ 15,747	$ 19,851	4	2	M5	24	11.6
1987	99	2724	110	$ 14,515	$ 17,390	$ 21,959	4	2	M5	23	11.6
1988	99	2735	110	$ 15,471	$ 18,171	$ 22,585	4	2	M5	23	11.7
1989	99	2763	128	$ 17,874	$ 20,588	$ 25,034	4	2	M5	24	10.5
1990	99	2787	128	$ 17,898	$ 20,309	$ 23,864	4	2	M5	24	10.5
1991	99	2818	140	$ 19,232	$ 21,074	$ 24,752	4	2.1	M5	22	9.9
1992	99	2776	140	$ 20,435	$ 21,851	$ 25,672	4	2.1	M5	23	9.8
1993	105	2810	140	$ 21,945	$ 22,913	$ 26,893	4	2.1	M5	22	9.9
1994	102	2950	155	$ 23,110	$ 23,331	$ 27,743	4	2.3	M5	22	9.5
1995	102	2980	155	$ 23,845	$ 23,553	$ 27,954	4	2.3	M5	23	9.6
1996	102	2990	150	$ 25,190	$ 24,460	$ 28,756	4	2.3	L4	22	9.9
1997	102	2990	150	$ 26,520	$ 25,697	$ 29,631	4	2.3	M5	24	9.8
1998	102	2990	150	$ 27,505	$ 26,840	$ 30,292	4	2	M5	24	9.8

Toyota Corolla – (Sub)Compact Car



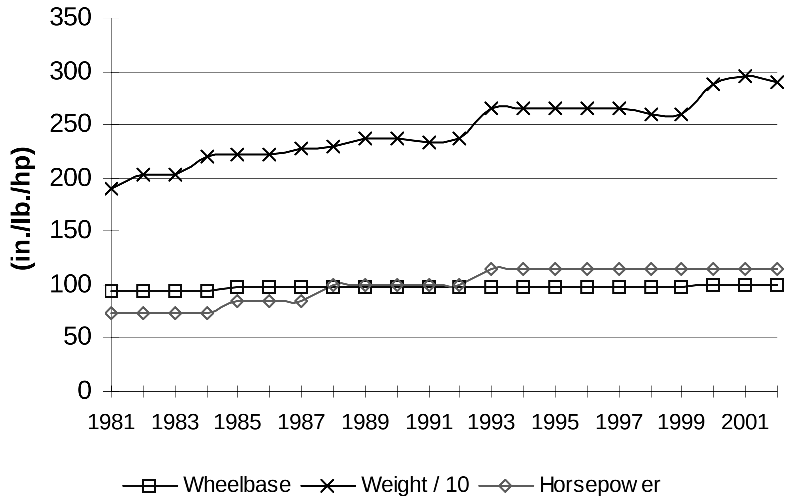


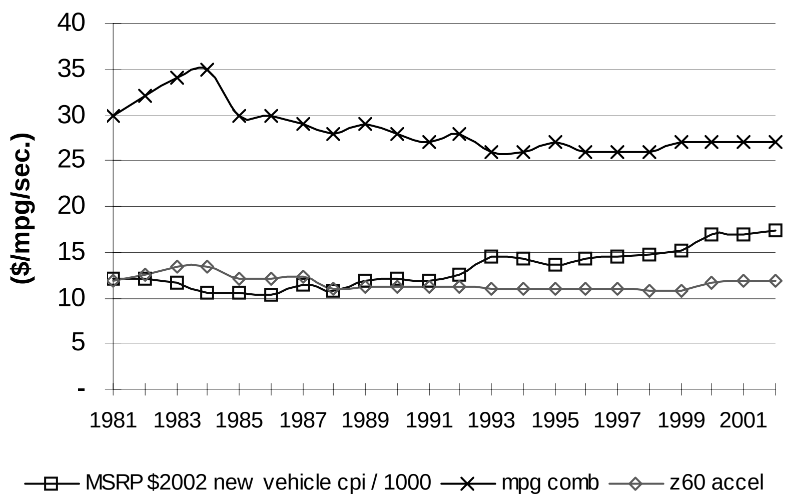


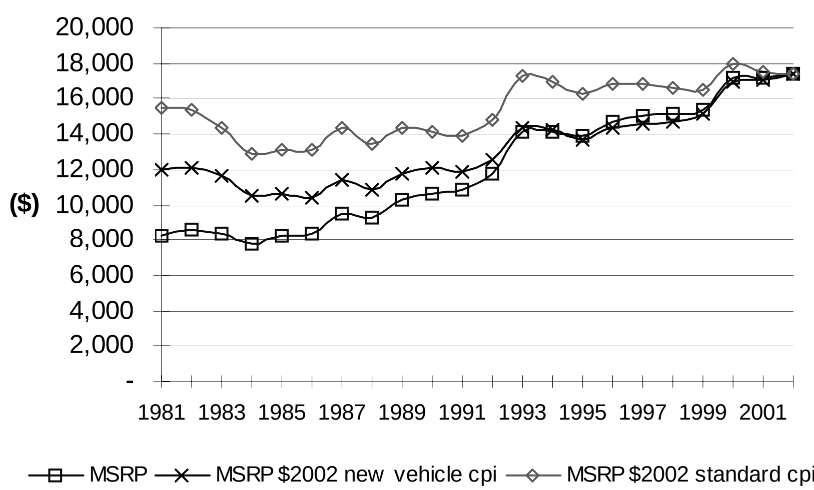
Toyota Corolla

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1975	93	2174	75	$ 2,711	$ 5,918	$ 7,997	4	.	.	27	13.4
1976	93	2227	75	$ 2,849	$ 5,847	$ 7,936	4	.	.	27	13.7
1977	93	2250	75	$ 3,708	$ 7,232	$ 9,707	4	1.6	A	27	13.8
1978	93	2240	75	$ 4,213	$ 7,631	$ 10,585	4	1.6	A	28	13.7
1979	93	2200	75	$ 4,758	$ 7,986	$ 10,913	4	1.6	M4	28	13.3
1980	93	2046	58	$ 4,758	$ 7,390	$ 9,831	4	1.8	A3	28	15.7
1981	95	2210	75	$ 4,828	$ 7,075	$ 9,127	4	1.8	M4	34	13.3
1982	95	2176	70	$ 5,448	$ 7,680	$ 9,711	4	1.8	M4	33	13.9
1983	95	2066	70	$ 5,448	$ 7,488	$ 9,329	4	1.6	A4	36	13.6
1984	96	2081	70	$ 6,498	$ 8,679	$ 10,705	4	1.6	M5	39	13.4
1985	96	2081	70	$ 6,938	$ 8,978	$ 11,065	4	1.6	M5	33	13.4
1986	96	2081	74	$ 7,148	$ 8,874	$ 11,186	4	1.6	M5	33	12.8
1987	96	2134	74	$ 8,178	$ 9,798	$ 12,372	4	1.6	M5	33	13.1
1988	96	2207	90	$ 8,998	$ 10,568	$ 13,136	4	1.6	M5	32	11.5
1989	96	2207	90	$ 9,453	$ 10,888	$ 13,239	4	1.6	M5	32	11.5
1990	96	2240	102	$ 9,013	$ 10,227	$ 12,017	4	1.6	M5	30	11.1
1991	96	2253	102	$ 9,273	$ 10,161	$ 11,934	4	1.6	M5	30	10.7
1992	96	2253	102	$ 9,713	$ 10,386	$ 12,202	4	1.6	M5	30	10.7
1993	97	2300	115	$ 11,803	$ 12,115	$ 14,464	4	1.8	L4	29	10.8
1994	96	2315	105	$ 12,303	$ 12,421	$ 14,770	4	1.6	M5	29	10.6
1995	97	2315	100	$ 12,775	$ 12,619	$ 14,977	4	1.8	L4	30	11.2
1996	97	2315	100	$ 13,148	$ 12,767	$ 15,009	4	1.8	L4	30	11.2
1997	97	2315	100	$ 13,418	$ 13,001	$ 14,992	4	1.6	M5	32	11.0
1998	97	2315	120	$ 12,328	$ 12,030	$ 13,577	4	1.8	M5	34	9.6
1999	97	2414	120	$ 12,638	$ 12,430	$ 13,633	4	1.8	M5	34	9.9
2000	97	2414	125	$ 12,873	$ 12,661	$ 13,437	4	1.8	M5	34	9.6
2001	97	2410	125	$ 13,048	$ 12,898	$ 13,260	4	1.8	M5	36	9.6
2002	97	2410	125	$ 13,053	$ 13,053	$ 13,053	4	1.8	M5	36	9.6

Volkswagen Jetta – (Sub)Compact Car



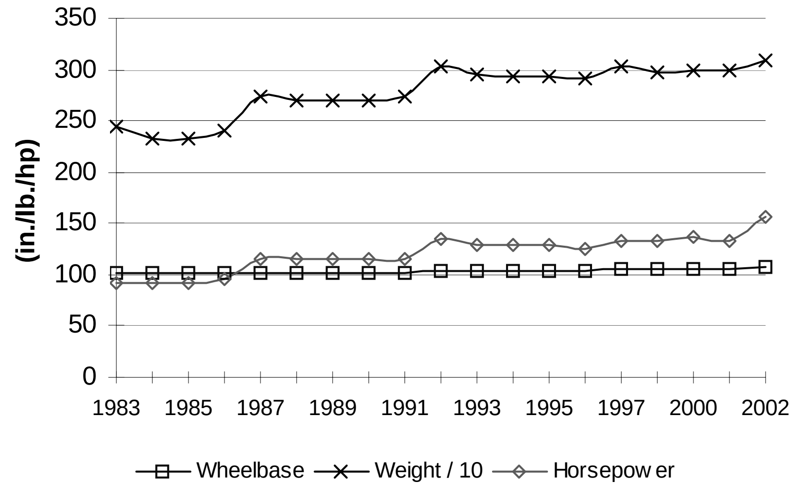


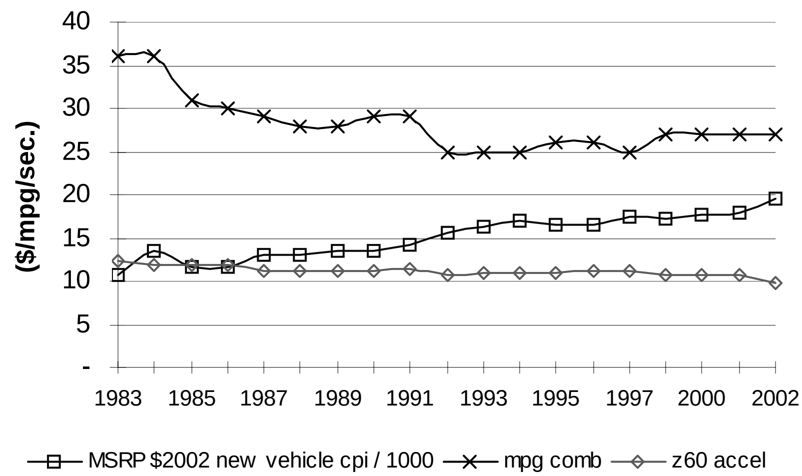


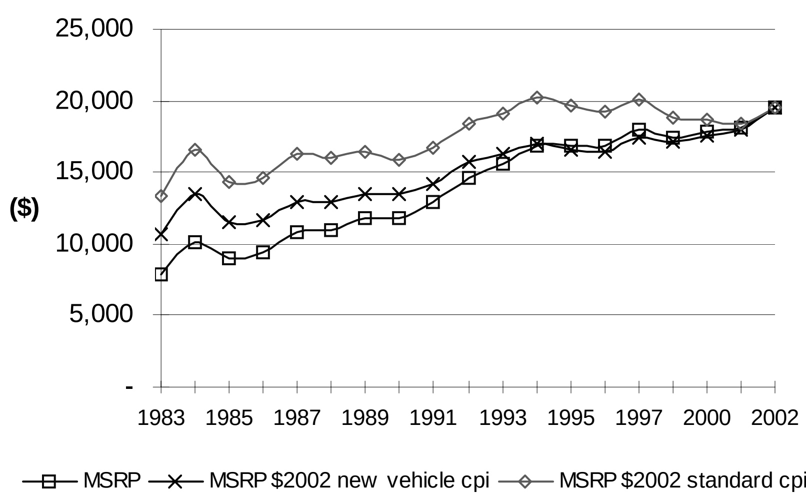
Volkswagen Jetta

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1981	95	1892	74	$ 8,195	$ 12,008	$ 15,491	4	1.7	M5	30	11.9
1982	95	2026	74	$ 8,595	$ 12,116	$ 15,321	4	1.7	M5	32	12.6
1983	95	2026	74	$ 8,350	$ 11,645	$ 14,298	4	1.6	M5	34	13.4
1984	95	2204	74	$ 7,850	$ 10,484	$ 12,932	4	1.7	M5	35	13.4
1985	97	2212	85	$ 8,195	$ 10,605	$ 13,070	4	1.8	M5	30	12.1
1986	97	2212	85	$ 8,370	$ 10,391	$ 13,099	4	1.8	M5	30	12.1
1987	97	2275	85	$ 9,510	$ 11,394	$ 14,387	4	1.8	M5	29	12.4
1988	97	2305	100	$ 9,210	$ 10,817	$ 13,445	4	1.8	M5	28	11.0
1989	97	2367	100	$ 10,230	$ 11,783	$ 14,328	4	1.8	M5	29	11.2
1990	97	2367	100	$ 10,615	$ 12,045	$ 14,153	4	1.8	M5	28	11.2
1991	97	2330	100	$ 10,815	$ 11,851	$ 13,919	4	1.8	M5	27	11.1
1992	97	2369	100	$ 11,740	$ 12,554	$ 14,749	4	1.8	M5	28	11.2
1993	97	2647	115	$ 14,140	$ 14,400	$ 17,328	4	2	M5	26	11.0
1994	97	2647	115	$ 14,140	$ 14,275	$ 16,975	4	2	M5	26	11.0
1995	97	2647	115	$ 13,865	$ 13,695	$ 16,254	4	2	M5	27	11.0
1996	97	2657	115	$ 14,725	$ 14,298	$ 16,809	4	2	M5	26	11.0
1997	97	2657	115	$ 15,070	$ 14,602	$ 16,838	4	2	M5	26	11.0
1998	97	2590	115	$ 15,095	$ 14,730	$ 16,624	4	2	M5	26	10.8
1999	97	2590	115	$ 15,345	$ 15,092	$ 16,553	4	2	M5	27	10.8
2000	99	2884	115	$ 17,225	$ 16,941	$ 17,980	4	2	M5	27	11.8
2001	99	2946	115	$ 17,225	$ 17,027	$ 17,505	4	2	M5	27	11.9
2002	99	2893	115	$ 17,400	$ 17,400	$ 17,400	4	1.8	M5	27	11.8

Toyota Camry – Compact/Midsize Car



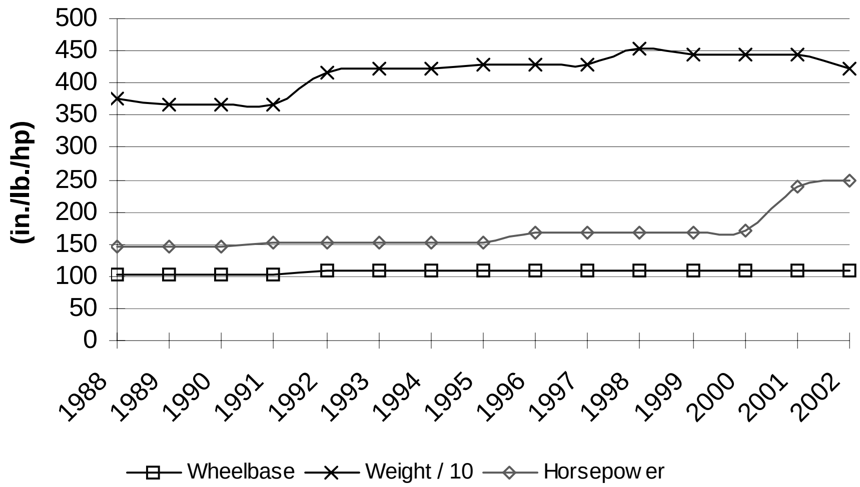


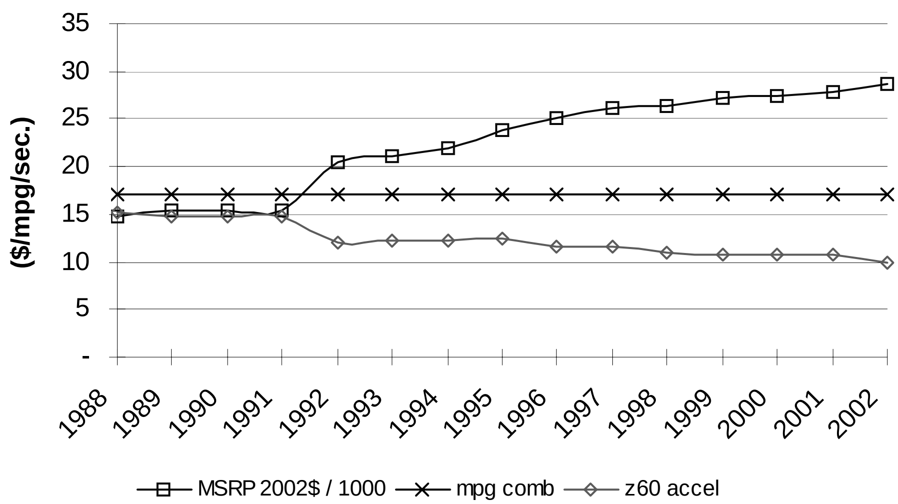


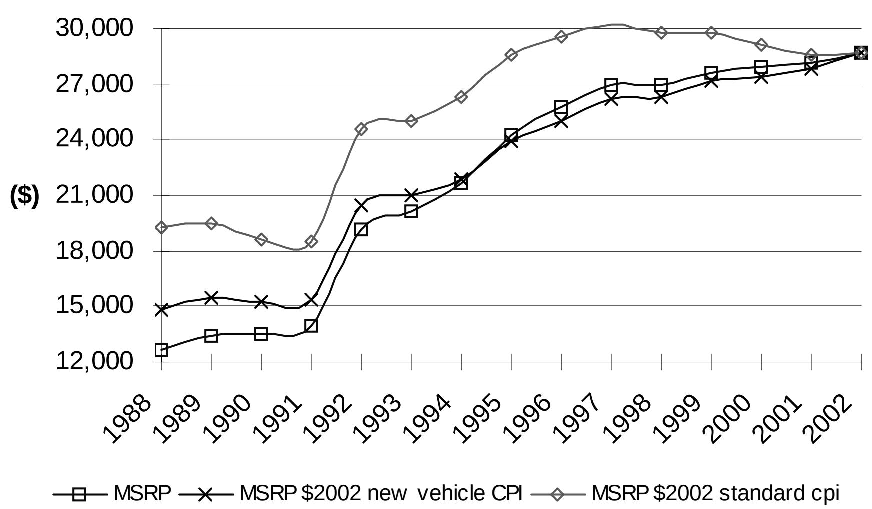
Toyota Camry

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1983	102	2445	92	$ 7,798	$ 10,717	$ 13,353	4	2	M5	36	12.3
1984	102	2326	92	$ 10,098	$ 13,487	$ 16,636	4	2	M5	36	11.8
1985	102	2326	92	$ 8,948	$ 11,579	$ 14,271	4	2	M5	31	11.8
1986	102	2403	95	$ 9,378	$ 11,642	$ 14,676	4	2	M5	30	11.8
1987	102	2734	115	$ 10,798	$ 12,937	$ 16,336	4	2	M5	29	11.3
1988	102	2690	115	$ 10,998	$ 12,917	$ 16,055	4	2	M5	28	11.1
1989	102	2690	115	$ 11,743	$ 13,526	$ 16,447	4	2	M5	28	11.1
1990	102	2690	115	$ 11,853	$ 13,450	$ 15,804	4	2	M5	29	11.1
1991	102	2743	115	$ 12,963	$ 14,204	$ 16,683	4	2	M5	29	11.3
1992	103	3030	135	$ 14,663	$ 15,679	$ 18,421	4	2.2	M5	25	10.8
1993	103	2943	130	$ 15,633	$ 16,323	$ 19,158	4	2.2	M5	25	10.9
1994	103	2932	130	$ 16,823	$ 16,984	$ 20,196	4	2.2	M5	25	10.8
1995	103	2932	130	$ 16,815	$ 16,609	$ 19,713	4	2.2	M5	26	10.8
1996	103	2910	125	$ 16,888	$ 16,398	$ 19,279	4	2.2	M5	26	11.1
1997	105	3035	133	$ 18,028	$ 17,468	$ 20,143	4	2.2	L4	25	11.1
1999	105	2976	133	$ 17,458	$ 17,170	$ 18,833	4	2.2	M5	27	10.8
2000	105	2998	136	$ 17,873	$ 17,579	$ 18,657	4	2.2	M5	27	10.6
2001	105	2998	133	$ 18,155	$ 17,946	$ 18,450	4	2.2	M5	27	10.8
2002	107	3086	157	$ 19,455	$ 19,455	$ 19,455	4	2.4	M5	27	9.7

Isuzu Trooper – Midsize SUV







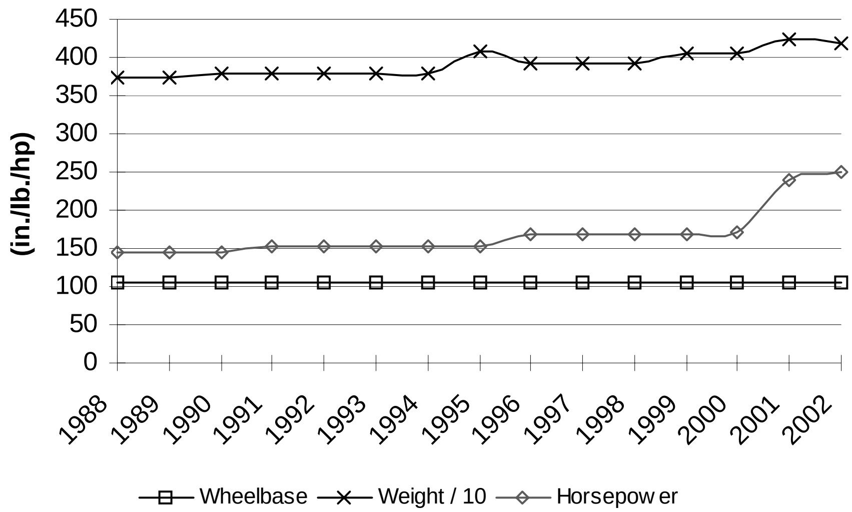
Isuzu Trooper

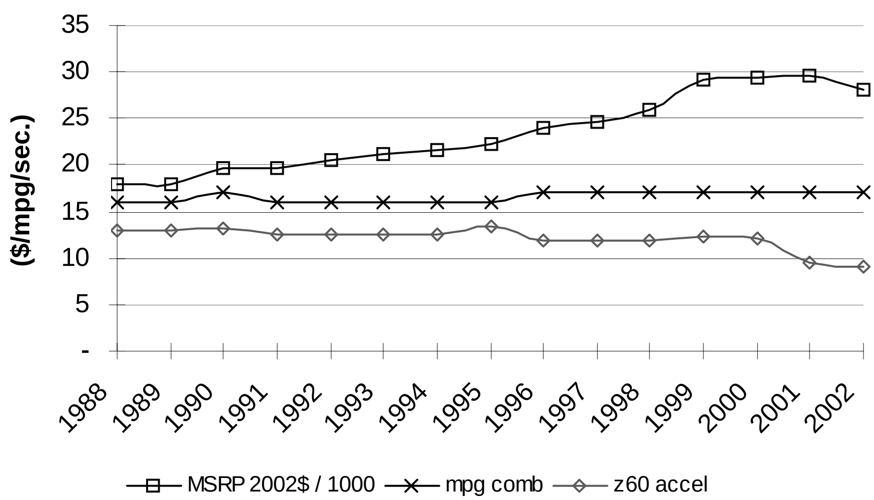
Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1988	104	3745	120	$12,639	$14,845	$19,220	4	2.6	L4	17	15.1
1989	104	3650	120	$13,408	$15,444	$19,452	4	2.6	M5	17	14.9
1990	104	3650	120	$13,489	$15,306	$18,567	4	2.6	M5	17	14.9
1991	104	3650	120	$13,998	$15,339	$18,489	4	2.6	M5	17	14.9
1992	109	4155	175	$19,169	$20,498	$24,579	6	3.2	M5	17	12.1
1993	109	4210	175	$20,119	$21,006	$25,048	6	3.2	M5	17	12.2
1994	109	4210	175	$21,650	$21,857	$26,281	6	3.2	M5	17	12.2
1995	109	4275	175	$24,220	$23,924	$28,590	6	3.2	M5	17	12.3
1996	109	4275	190	$25,805	$25,057	$29,588	6	3.2	M5	17	11.6
1997	109	4275	190	$26,995	$26,157	$30,258	6	3.2	M5	17	11.6
1998	109	4530	215	$26,995	$26,343	$29,794	6	3.5	M5	17	10.9
1999	109	4455	215	$27,595	$27,140	$29,798	6	3.5	M5	17	10.8
2000	109	4455	215	$27,895	$27,435	$29,142	6	3.5	M5	17	10.8
2001	109	4455	215	$28,140	$27,816	$28,585	6	3.5	M5	17	10.8
2002	109	4238	230	$28,715	$28,715	$28,715	6		M5	17	9.8

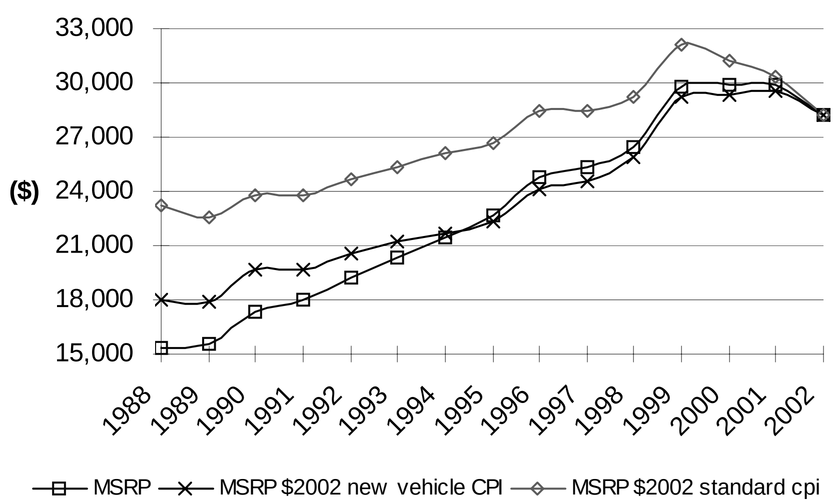
Nissan Pathfinder

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1988	104	3735	145	$15,299	$17,969	$23,265	6	3	M5	16	13.0
1989	104	3735	145	$15,569	$17,933	$22,588	6	3	M5	16	13.0
1990	104	3798	145	$17,295	$19,625	$23,805	6	3	L4	17	13.1
1991	104	3795	153	$17,970	$19,691	$23,736	6	3	L4	16	12.6
1992	104	3795	153	$19,210	$20,542	$24,632	6	3	L4	16	12.6
1993	104	3795	153	$20,370	$21,268	$25,360	6	3	L4	16	12.6
1994	104	3795	153	$21,479	$21,684	$26,073	6	3	L4	16	12.6
1995	104	4090	153	$22,619	$22,342	$26,701	6	3	L4	16	13.3
1996	106	3920	168	$24,804	$24,085	$28,440	6	3.3	M5	17	11.9
1997	106	3920	168	$25,369	$24,581	$28,435	6	3.3	M5	17	11.9
1998	106	3920	168	$26,489	$25,849	$29,235	6	3.3	M5	17	11.9
1999	106	4050	168	$29,739	$29,249	$32,113	6	3.3	M5	17	12.2
2000	106	4050	170	$29,869	$29,377	$31,205	6	3.3	M5	17	12.1
2001	106	4250	240	$29,869	$29,525	$30,341	6	3.5	M5	17	9.5
2002	106	4190	250	$28,189	$28,189	$28,189	6	3.5	M5	17	9.1

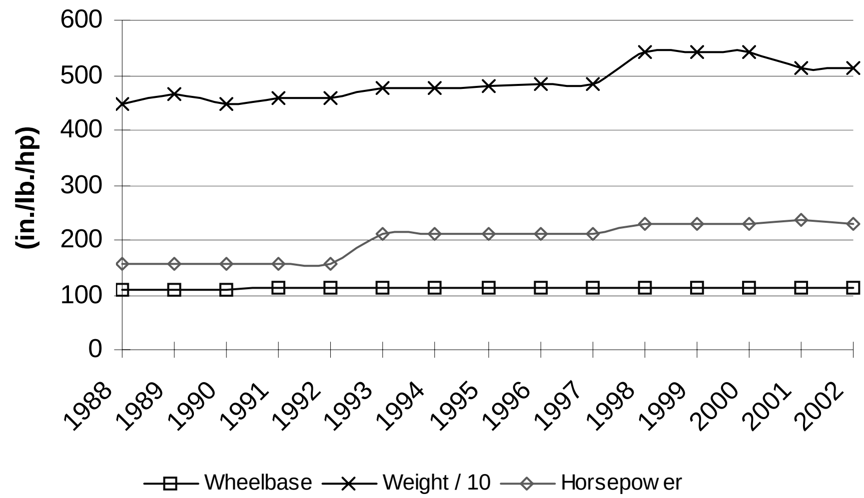
Nissan Pathfinder – Midsize SUV

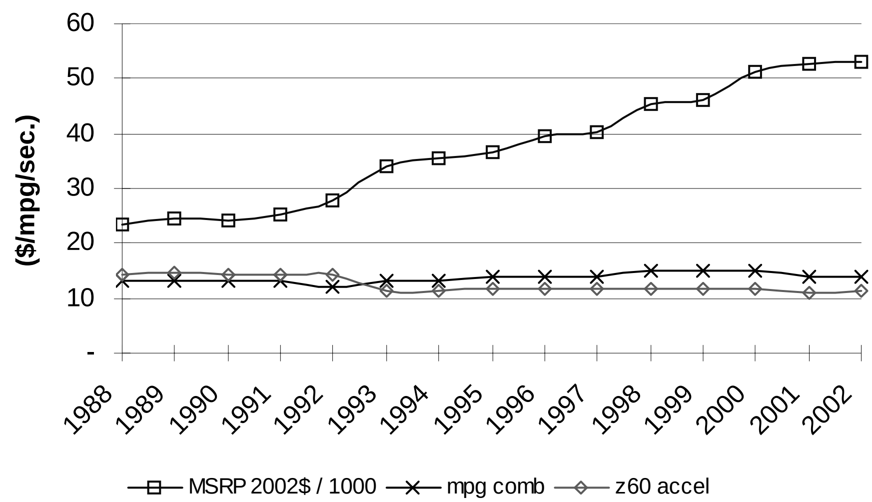


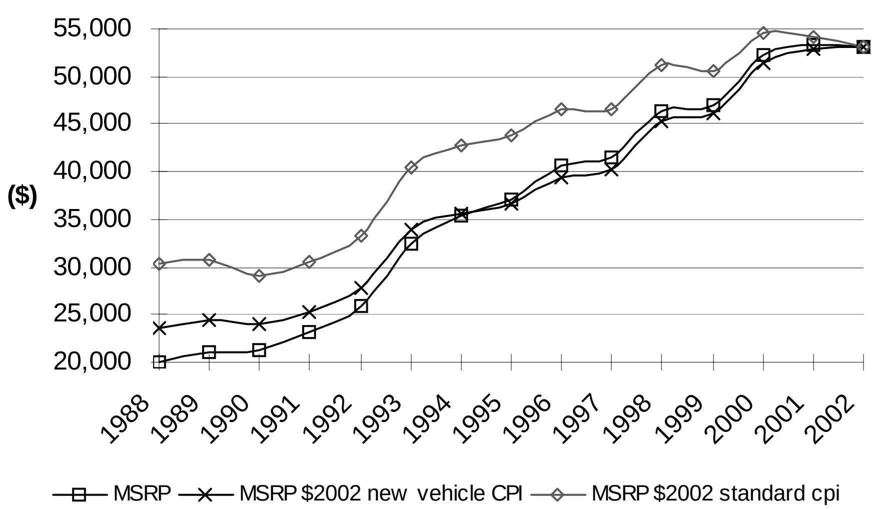




Toyota Land Cruiser – Large SUV







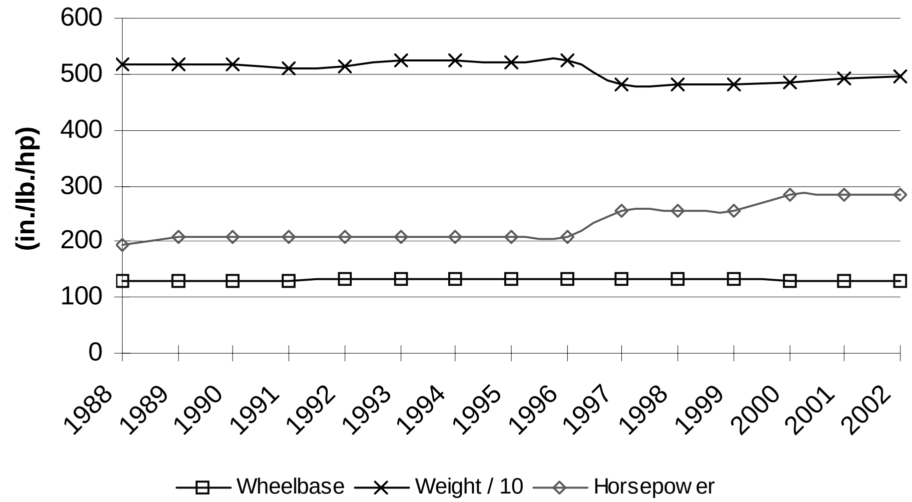
Toyota Land Cruiser

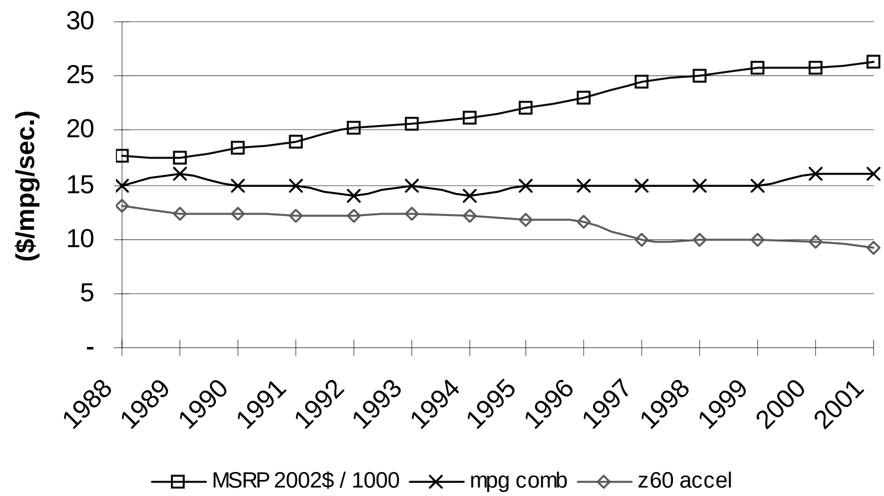
Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1988	108	4480	155	$19,998	$23,488	$30,411	6	4	L4	13	14.1
1989	108	4650	155	$21,153	$24,365	$30,689	6	4	L4	13	14.5
1990	108	4480	155	$21,163	$24,014	$29,129	6	4	L4	13	14.1
1991	112	4597	155	$23,063	$25,272	$30,463	6	4	L4	13	14.4
1992	112	4597	155	$25,923	$27,720	$33,240	6	4	L4	12	14.4
1993	112	4760	212	$32,453	$33,884	$40,403	6	4.5	L4	13	11.5
1994	112	4780	212	$35,298	$35,635	$42,848	6	4.5	L4	13	11.5
1995	112	4800	212	$37,105	$36,651	$43,800	6	4.5	L4	14	11.5
1996	112	4834	212	$40,678	$39,499	$46,641	6	4.5	L4	14	11.6
1997	112	4834	212	$41,488	$40,200	$46,503	6	4.5	L4	14	11.6
1998	112	5401	230	$46,370	$45,249	$51,178	8	4.7	L4	15	11.8
1999	112	5401	230	$46,898	$46,125	$50,642	8	4.7	L4	15	11.8
2000	112	5401	230	$52,208	$51,348	$54,543	6	4.7	L4	15	11.8
2001	112	5115	235	$53,405	$52,790	$54,249	8	4.7	L4	14	11.1
2002	112	5115	230	$53,105	$53,105	$53,105	8	4.7	L4	14	11.3

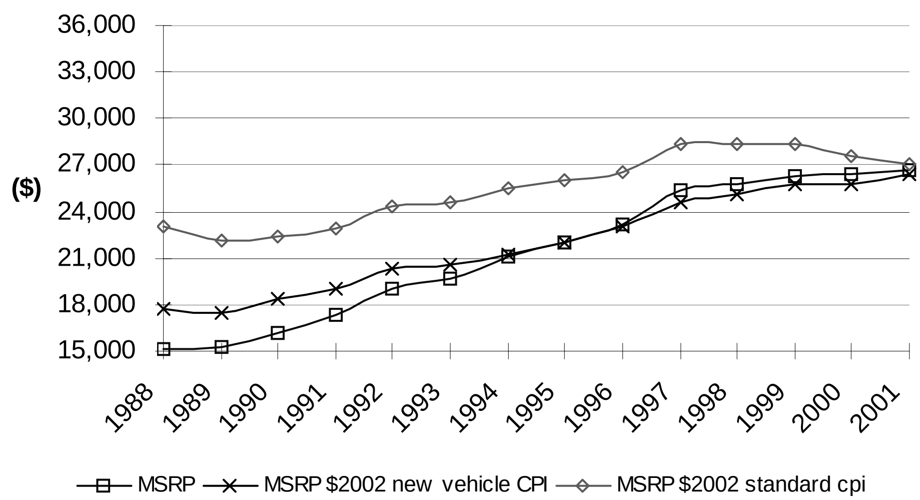
Chevrolet Suburban

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1988	130	5178	195	$15,107	$17,743	$22,973	8	5.7	L4	15	13.1
1989	130	5178	210	$15,215	$17,525	$22,074	8	5.7	L4	16	12.3
1990	130	5178	210	$16,225	$18,411	$22,333	8	5.7	L4	15	12.3
1991	130	5100	210	$17,340	$19,001	$22,904	8	5.7	L4	15	12.2
1992	132	5125	210	$19,003	$20,320	$24,367	8	5.7	L4	14	12.2
1993	132	5230	210	$19,720	$20,590	$24,551	8	5.7	L4	15	12.4
1994	132	5230	210	$21,046	$21,247	$25,548	8	5.7	L4	14	12.2
1995	132	5199	210	$22,000	$22,050	$25,970	8	5.7	L4	15	11.8
1996	132	5230	210	$23,200	$23,000	$26,601	8	5.7	L4	15	11.6
1997	132	4802	255	$25,323	$24,537	$28,384	8	5.7	L4	15	10.0
1998	132	4820	255	$25,740	$25,118	$28,409	8	5.7	L4	15	10.0
1999	132	4820	255	$26,230	$25,798	$28,324	8	5.7	L4	15	10.0
2000	130	4866	285	$26,400	$25,798	$27,613	8	5.3	L4	16	9.7
2001	130	4914	285	$26,656	$26,349	$27,077	8	5.3	L4	16	9.3

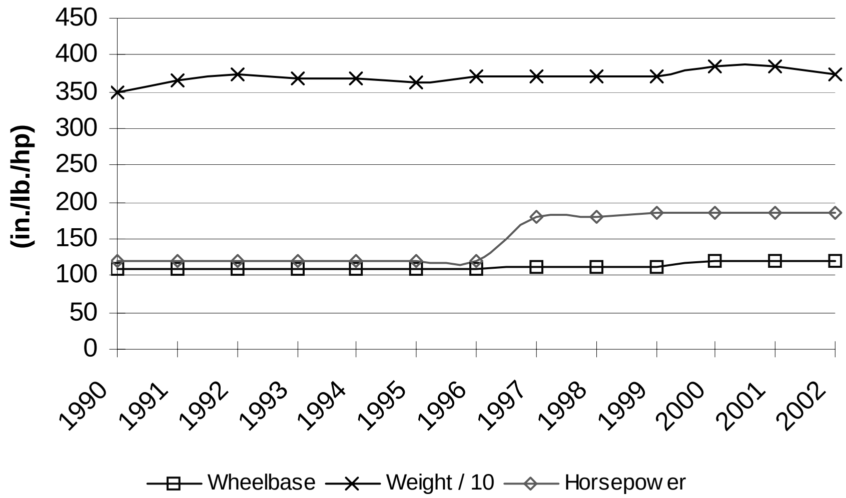
Chevrolet Suburban – Large SUV

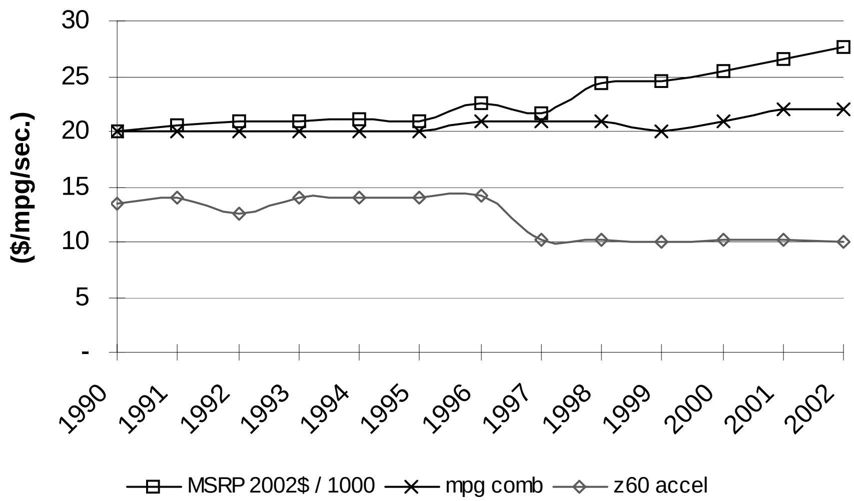


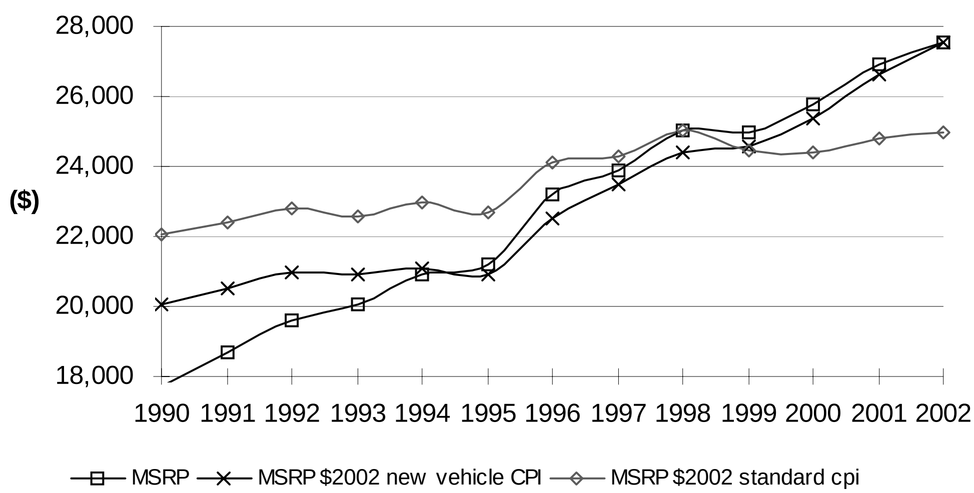




Oldsmobile Silhouette – Minivan







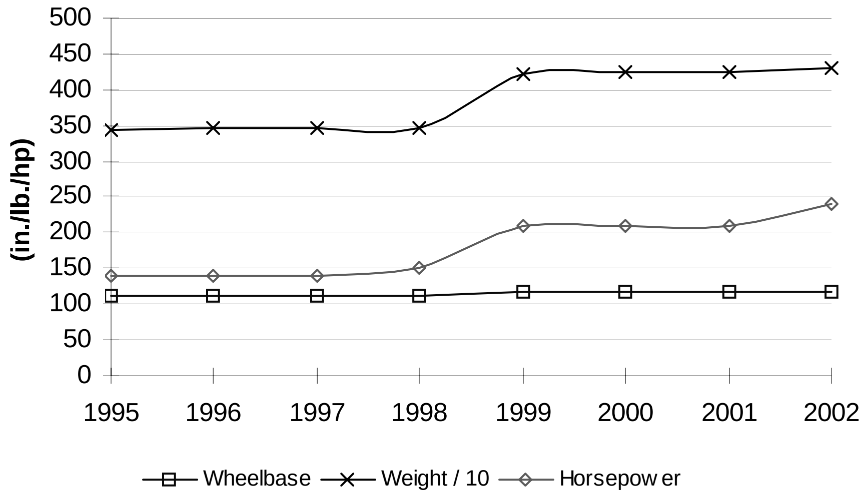
Oldsmobile Silhouette

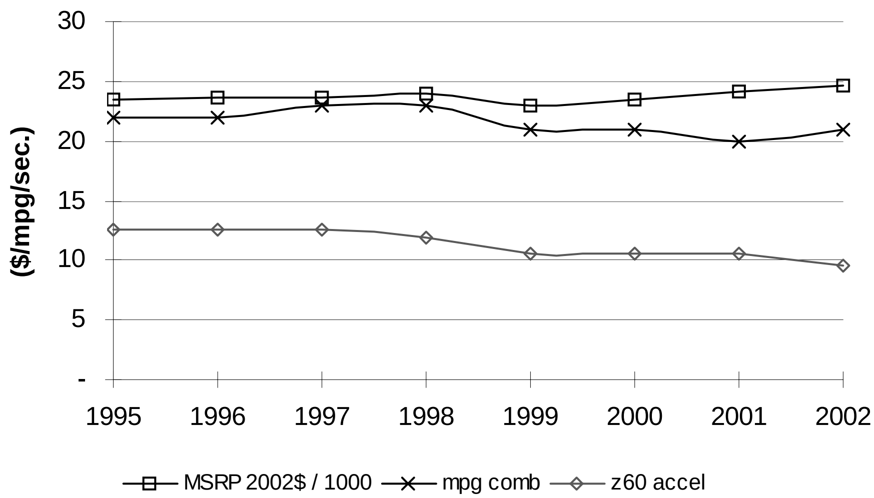
Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1990	110	3495	120	$17,695	$20,079	$22,068	6	3.1	L3	20	13.5
1991	110	3648	120	$18,705	$20,496	$22,386	6	3.1	L3	20	13.9
1992	110	3735	120	$19,625	$20,985	$22,800	6	3.1	L3	20	12.5
1993	110	3676	120	$20,029	$20,912	$22,593	6	3.1	L3	20	14.0
1994	110	3676	120	$20,895	$21,095	$22,982	6	3.1	L3	20	14.0
1995	110	3633	120	$21,200	$20,941	$22,675	6	3.8	L4	20	14.0
1996	110	3704	120	$23,200	$22,527	$24,102	6	2.8	L4	21	14.1
1997	112	3702	180	$23,900	$23,466	$24,272	6	3.3	L4	21	10.2
1998	112	3710	180	$25,000	$24,396	$25,000	6	3.4	L4	21	10.2
1999	112	3710	185	$24,990	$24,578	$24,450	6	3.4	L4	20	10.0
2000	120	3832	185	$25,800	$25,375	$24,422	6	3.4	L4	21	10.2
2001	120	3832	185	$26,920	$26,610	$24,777	6	3.4	L4	22	10.2
2002	120	3730	185	$27,560	$27,560	$24,971	6	3.4	L4	22	10.0

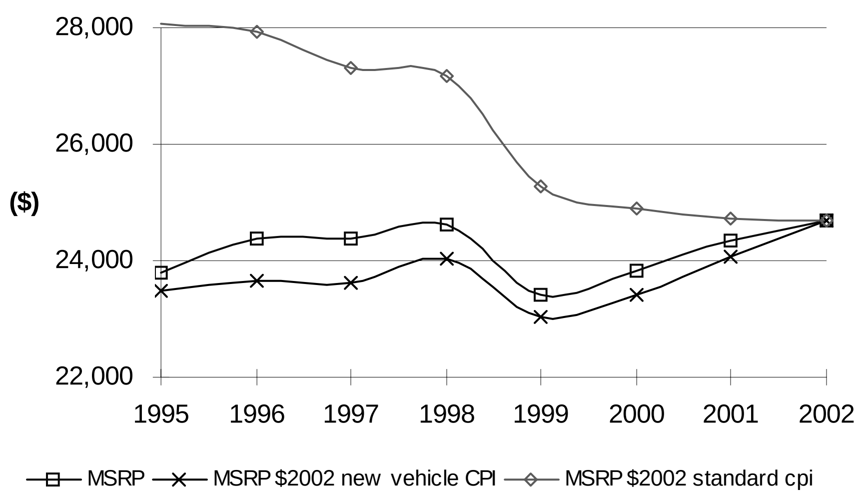
Honda Odyssey

Year	Wheel base	Curb Wgt	Horse power	MSRP Current $	MSRP $2002 new vehicle cpi	MSRP $2002 standard cpi	Cyl	Dis (L)	Tran	mpg cmb	Zero to 60 accl (sec)
1995	111	3435	140	$23,790	$23,499	$28,083	4	2.2	L4	22	13.0
1996	111	3473	140	$24,365	$23,659	$27,937	4	2.2	L4	22	13.1
1997	111	3473	140	$24,365	$23,608	$27,310	4	2.2	L4	23	13.1
1998	111	3450	150	$24,615	$24,020	$27,167	4	2.3	L4	23	12.3
1999	118	4211	210	$23,415	$23,029	$25,284	6	3.5	L4	21	10.6
2000	118	4233	210	$23,815	$23,423	$24,880	6	3.5	L4	21	10.7
2001	118	4248	210	$24,340	$24,060	$24,725	6	3.5	L4	20	10.8
2002	118	4299	240	$24,690	$24,690	$24,690	6	3.5	L5	21	9.1

Honda Odyssey – Minivan

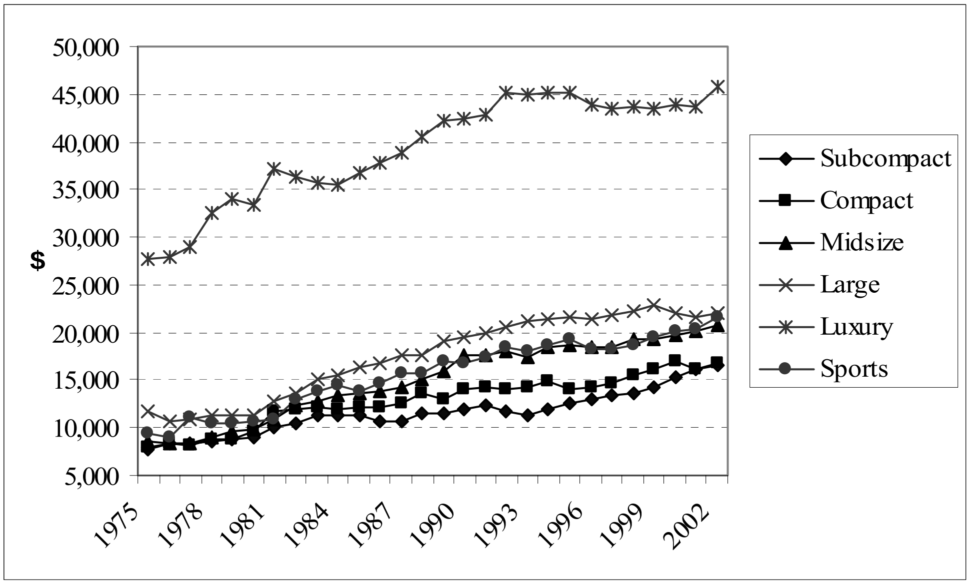


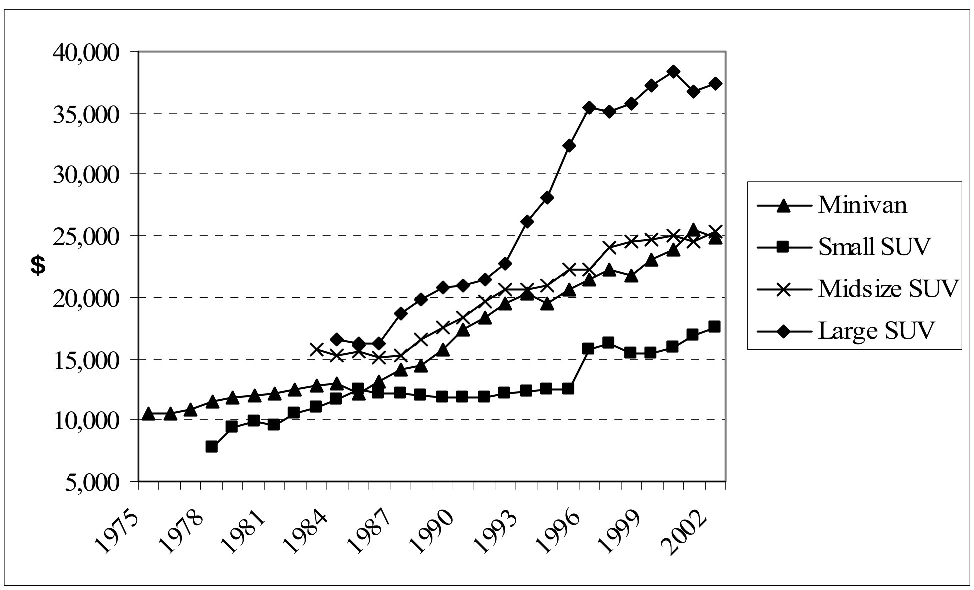




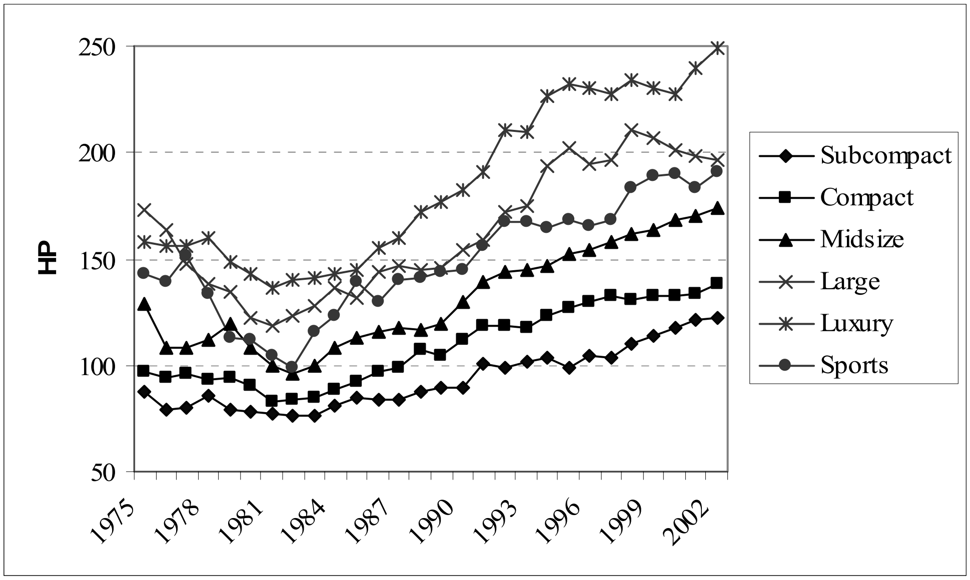
Appendix III: Average Attribute Trends Generated from the ITS Davis Database – MSRP, Acceleration, Fuel Economy, Curb Weight, Horsepower

Manufacturer's Suggested Retail Price ($2002)





Horsepower



250
200
150
100
50
HP
1975
1978
1981
1984
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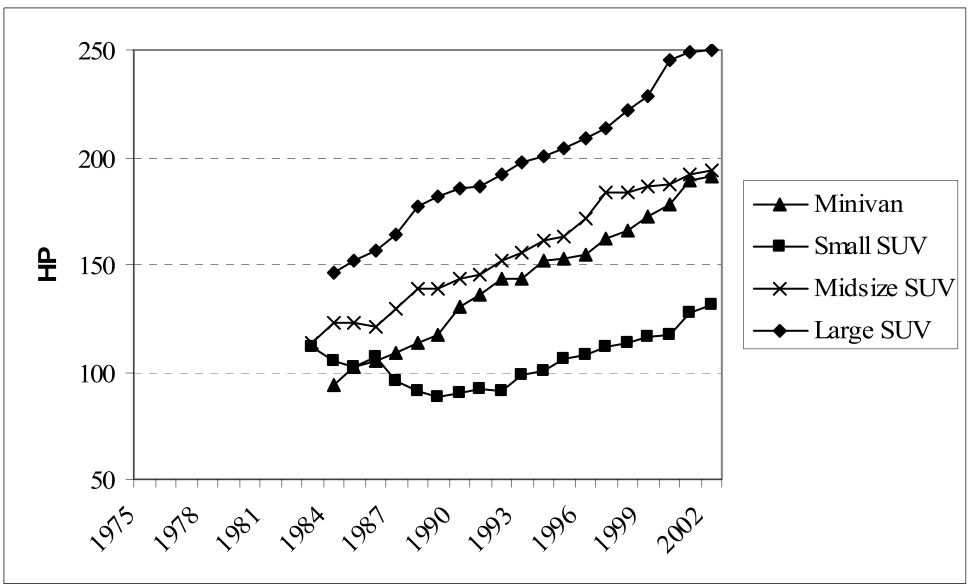
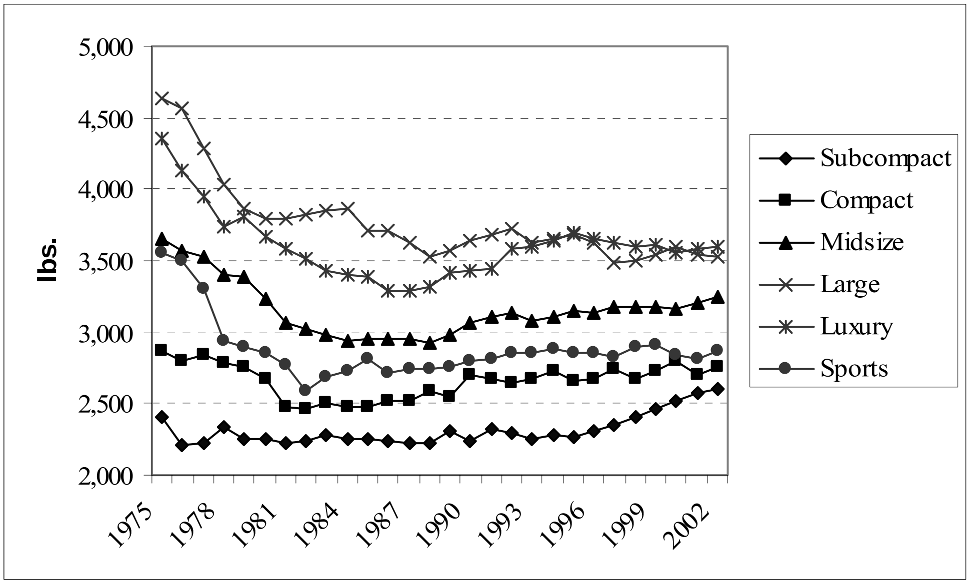
1990
1993
1996
1999
2002
Subcompact
Compact
Midsize
Large
Luxury
Sports



250
200
150
100
50
HP
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
Minivan
Small SUV
Midsize SUV
Large SUV

Curb Weight



5,000
4,500
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lbs.
1975
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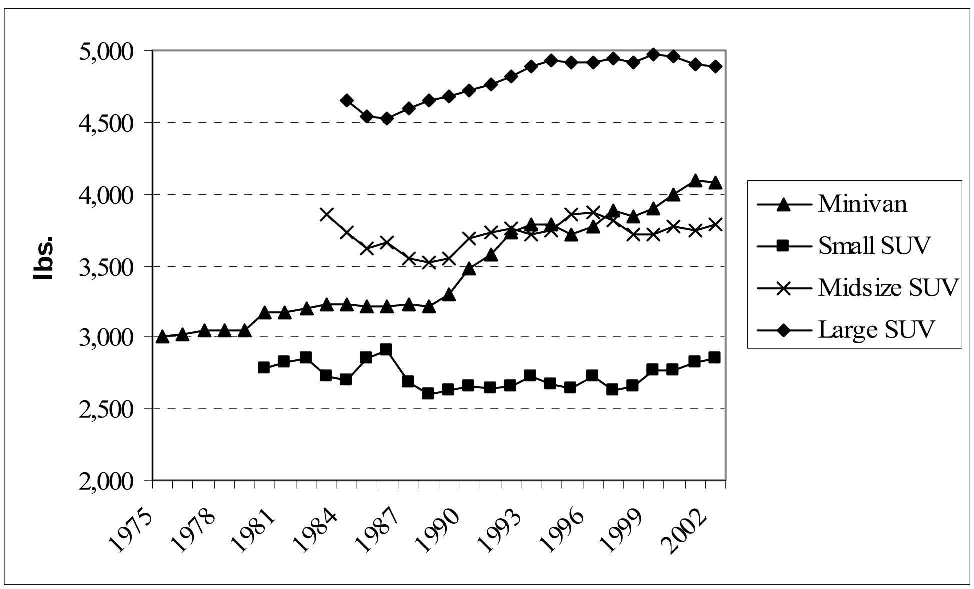
Subcompact
Compact
Midsize
Large
Luxury
Sports



5,000
4,500
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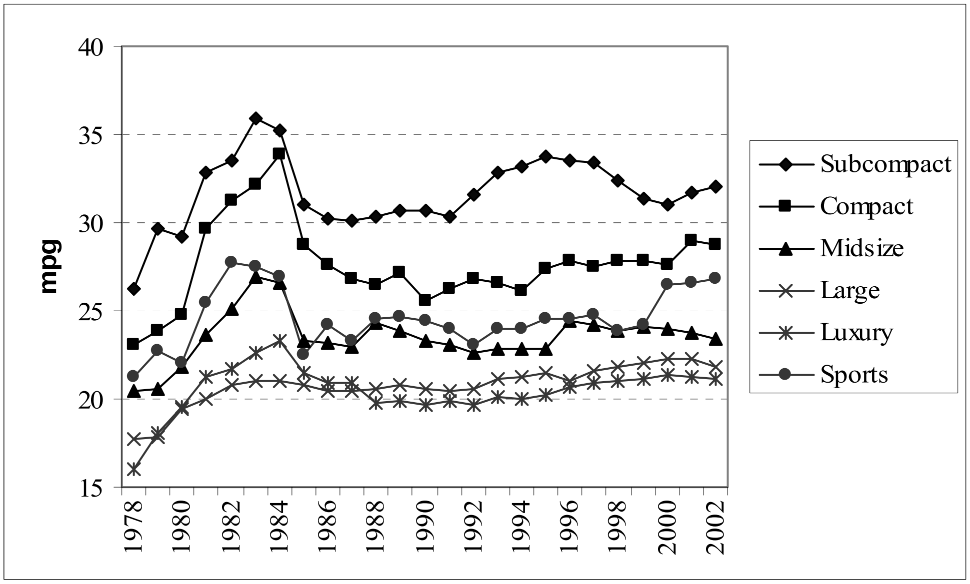
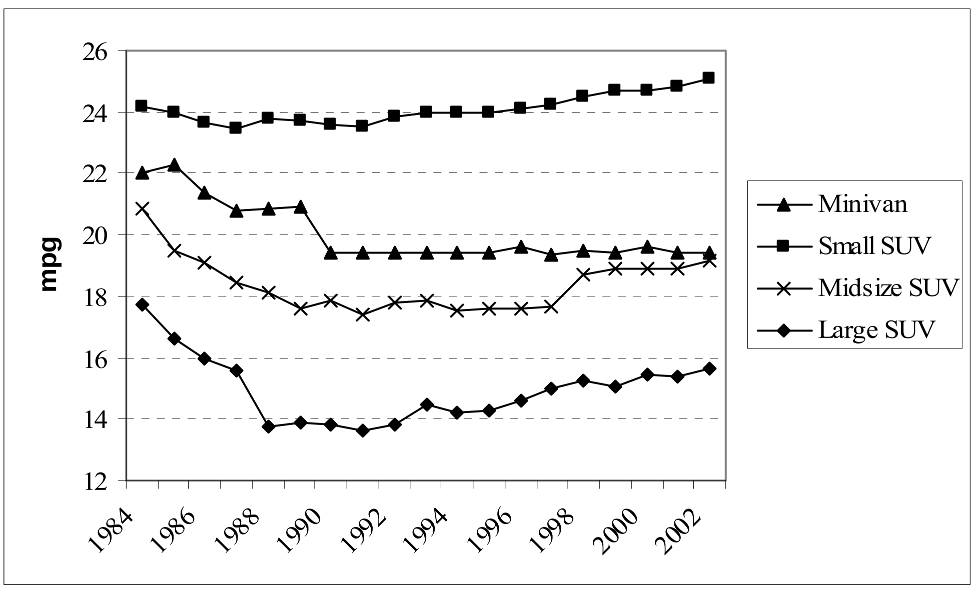
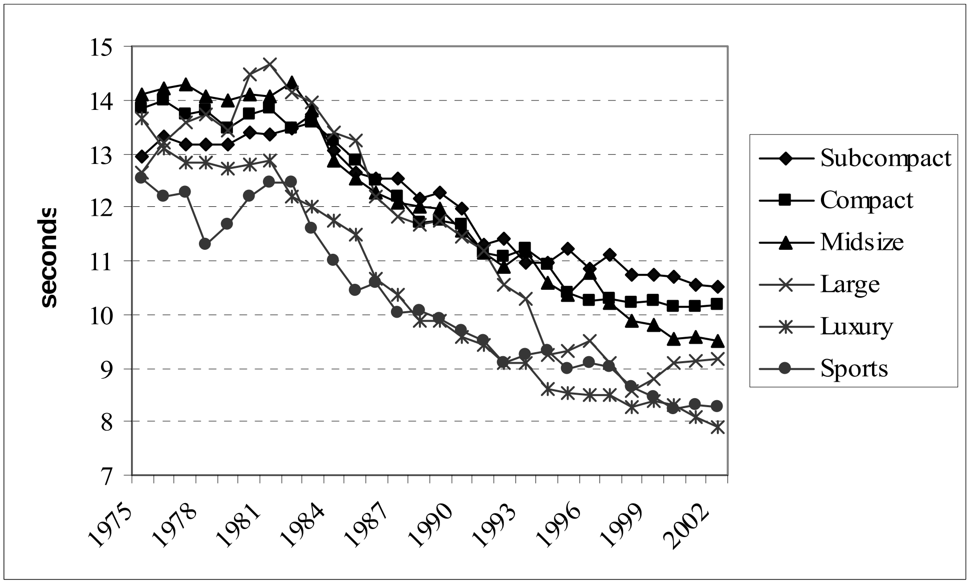
lbs.
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
Minivan
Small SUV
Midsize SUV
Large SUV

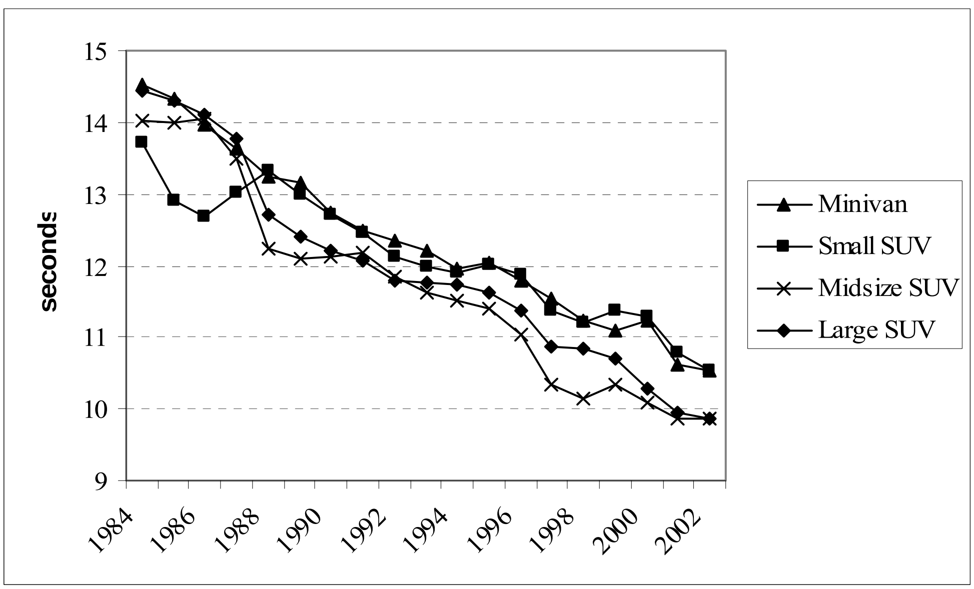
Combined Adjusted Fuel Economy from EPA





Zero to Sixty mph Acceleration Time





Appendix IV: Vehicle Technology Trends with respect to Fuel Economy and Performance for Passenger Cars and Light Trucks (1975 to 2003)

Source: Reference 5, p. 6-9, Table 2 and p. 12-13, Table 3.

Passenger Cars

< - - - - - - - Measured Characteristics - - - - - - - >										< - -Percent By: - - >		
Model Year	Sales (000)	Frac	Adj 55/45 mpg	Vol Cu-Ft	Inertia Weight (lb)	Eng HP	HP/WT	0-60 Time	Top Spd	Vehicle Size		
										Small	Mid	Large
1975	8237	80.6%	13.5		4057	136	0.0331	14.2	111	55.4	23.3	21.3
1976	9722	78.8%	14.9		4058	134	0.0324	14.4	110	55.4	25.2	19.4
1977	11300	80.0%	15.6	110	3943	133	0.0335	14	111	51.9	24.5	23.5
1978	11175	77.3%	16.9	109	3587	124	0.0342	13.7	111	44.7	34.4	21
1979	10794	77.8%	17.2	108	3484	119	0.0338	13.8	110	43.7	34.2	22.1
1980	9443	83.5%	20	104	3101	100	0.0322	14.3	107	54.4	34.4	11.3
1981	8733	82.7%	21.4	106	3075	99	0.032	14.4	106	51.5	36.4	12.2
1982	7819	80.3%	22.2	106	3054	99	0.032	14.4	106	56.5	31	12.5
1983	8002	77.7%	22.1	108	3111	104	0.033	14	108	53.1	31.8	15.1
1984	10675	76.1%	22.4	107	3098	106	0.0339	13.8	109	57.4	29.4	13.2
1985	10791	74.6%	23	108	3092	111	0.0355	13.3	111	55.7	28.9	15.4
1986	11015	71.7%	23.8	107	3040	111	0.036	13.2	111	59.5	27.9	12.6
1987	10731	72.2%	24	106	3030	112	0.0365	13	112	63.5	24.3	12.2
1988	10736	70.2%	24.4	107	3046	116	0.0375	12.8	113	64.8	22.3	12.8
1989	10018	69.3%	24	107	3099	121	0.0387	12.5	115	58.3	28.2	13.5
1990	8810	69.8%	23.7	107	3175	129	0.0401	12.1	117	58.6	28.7	12.8
1991	8524	67.8%	23.9	106	3153	132	0.0413	11.8	118	61.5	26.2	12.3
1992	8108	66.6%	23.6	108	3239	141	0.0428	11.5	120	56.5	27.8	15.6
1993	8457	64.0%	24.1	108	3207	138	0.0425	11.6	120	57.2	29.5	13.3
1994	8414	60.2%	24	108	3249	143	0.0432	11.4	121	58.5	26.1	15.4
1995	9396	62.0%	24.2	108	3262	152	0.046	10.9	125	57.3	28.6	14
1996	7890	60.0%	24.2	108	3281	154	0.0464	10.8	125	54.3	32	13.6
1997	8335	57.7%	24.3	108	3274	156	0.0469	10.7	126	55.1	30.6	14.3
1998	7972	55.2%	24.4	108	3306	159	0.0475	10.6	127	49.4	39.1	11.4
1999	8446	55.3%	24.1	109	3365	164	0.0481	10.5	128	47.4	40	12.5
2000	9124	55.1%	24.1	109	3369	168	0.0492	10.4	129	47.5	34.3	18.2
2001	8405	53.9%	24.3	109	3379	168	0.0492	10.3	129	50.9	32.3	16.8
2002	8190	52.2%	24.3	109	3405	175	0.0507	10.1	131	48.7	34.8	16.4
2003	8388	52.4%	24.8	109	3410	175	0.0508	10.1	131	52	32.7	15.4

Model Year	Engine		HP/ CID	Drivetrain		Transmission		FI	Fuel Metering			DSL	Four Valve
	CID	HP		FWD	4WD	Manual	Lock		Port	TBI	Carb		
1975	288	136	0.515	6.5	0	19.9	0	5.1	5.1	0	94.6	0.2	0
1976	287	134	0.502	5.8	0	17.1	0	3.2	3.2	0	96.6	0.3	0
1977	279	133	0.516	6.8	0	16.8	0	4.2	4.2	0	95.3	0.5	0
1978	251	124	0.538	9.6	0	20.2	6.7	5.1	5.1	0	94	0.9	0
1979	238	119	0.545	11.9	0.3	22.3	8	4.7	4.7	0	93.2	2.1	0
1980	188	100	0.583	29.7	0.9	31.9	16.5	6.9	6.2	0.7	88.7	4.4	0
1981	182	99	0.594	37	0.7	30.4	33.3	8.8	6.1	2.6	85.3	5.9	0
1982	175	99	0.609	45.6	0.8	29.7	51.4	17	7.2	9.8	78.4	4.7	0
1983	182	104	0.615	47.3	3.1	26.5	56.7	28.3	9.5	18.9	69.6	2.1	0
1984	179	106	0.637	53.7	1	24.1	58.3	39.4	15	24.4	58.9	1.7	0
1985	177	111	0.671	61.6	2.1	22.8	58.7	53.5	21.4	32	45.6	0.9	0
1986	167	111	0.701	71.1	1.1	24.8	58	65.1	36.7	28.4	34.5	0.3	1.6
1987	162	112	0.732	77	1.1	24.9	59.5	73	42.5	30.5	26.8	0.3	5.6
1988	160	116	0.759	81.7	0.8	24.3	66.1	83.7	53.7	30	16.3	0	10.4
1989	163	121	0.783	82.5	1	21	69.3	90.2	62.4	27.8	9.7	0	12.8
1990	163	129	0.829	84.6	1	19.6	72.9	98.6	77.5	21.1	1.4	0	25.7
1991	163	132	0.851	83.2	1.4	20.5	73.5	99.8	78	21.8	0	0.1	28.2
1992	170	141	0.868	80.8	1.1	17.4	76.4	99.9	89.5	10.4	0	0.1	29.7
1993	166	138	0.865	85.1	1.2	17.8	76.9	100	91.6	8.4	0	0	32.8
1994	168	143	0.884	84.4	0.4	16.7	79.3	100	94.9	5.1	0	0	38.9
1995	167	152	0.945	82	1.2	16.3	81.9	99.9	98.8	1.2	0	0.1	52.1
1996	165	154	0.958	86.5	1.5	14.9	83.6	99.9	98.8	1.1	0	0.1	56.2
1997	164	156	0.974	86.5	1.7	13.5	85.8	99.9	99.1	0.8	0	0.1	57.4
1998	164	159	0.993	87	2.3	12.3	87.3	99.8	99.7	0.1	0	0.2	60.5
1999	166	164	1.009	86.5	3	11	88.4	99.8	99.7	0.1	0	0.2	59.7
2000	165	168	1.032	84.9	2.1	11.2	87.7	99.8	99.7	0.1	0	0.2	63.2
2001	165	168	1.042	84.1	3.2	11.4	87.5	99.7	99.7	0	0	0.3	61.8
2002	168	175	1.063	83.1	3.8	14	85.1	99.8	99.8	0	0	0.2	64.5
2003	165	175	1.083	82.4	3.6	14.7	84.7	99.6	99.6	0	0	0.4	70.4

Light Trucks

< - - - - - - - Measured Characteristics - - - - - - - >									< - - - - - Percent By: - - - - - >					
Model Year	Sales (000)	Frac	Adj 55/45 mpg	Inertia Weight (lb)	Eng HP	HP/WT	0-60 Time	Top Spd	Vehicle Size			Vehicle Type		
									Small	Mid	Large	Van	SUV	Pickup
1975	1987	19.4%	11.6	4072	142	0.035	13.6	114	10.9	24.2	64.9	23	9.4	67.6
1976	2612	21.2%	12.2	4154	141	0.034	13.8	113	9	20.3	70.7	19.2	9.3	71.4
1977	2823	20.0%	13.3	4135	147	0.036	13.3	115	11.1	20.3	68.5	18.2	10	71.8
1978	3273	22.7%	12.9	4151	146	0.035	13.4	114	10.9	22.7	66.3	19.1	11.6	69.3
1979	3088	22.2%	12.5	4251	138	0.033	14.3	111	15.2	19.5	65.3	15.6	13	71.5
1980	1863	16.5%	15.8	3868	121	0.031	14.5	108	28.4	17.6	54	13	9.9	77.1
1981	1821	17.3%	17.1	3805	119	0.031	14.6	108	23.2	19.1	57.7	13.5	7.5	79.1
1982	1914	19.7%	17.4	3805	120	0.032	14.5	109	21.1	31	47.9	16.2	8.5	75.3
1983	2300	22.3%	17.8	3763	118	0.031	14.5	108	16.6	45.9	37.6	16.6	12.6	70.8
1984	3345	23.9%	17.4	3782	118	0.031	14.7	108	19.5	46.4	34.1	20.2	18.7	61.1
1985	3669	25.4%	17.5	3795	124	0.033	14.1	110	19.2	48.5	32.3	23.3	20	56.6
1986	4350	28.3%	18.3	3737	123	0.033	14	110	23.5	48.5	28	24	17.8	58.2
1987	4134	27.8%	18.4	3712	131	0.035	13.3	113	19.9	59.6	20.6	26.9	21.1	51.9
1988	4559	29.8%	18.1	3841	141	0.037	12.9	115	15	57.2	27.8	24.8	21.2	53.9
1989	4435	30.7%	17.8	3921	146	0.037	12.8	116	13.9	58.9	27.2	28.8	20.9	50.3
1990	3805	30.2%	17.7	4005	151	0.038	12.6	117	13.4	57.1	29.6	33.2	18.6	48.2
1991	4049	32.2%	18.1	3948	150	0.038	12.6	117	11.4	67.2	21.4	25.5	27	47.4
1992	4064	33.4%	17.8	4055	155	0.038	12.5	118	10.4	64	25.6	30	24.7	45.3
1993	4754	36.0%	17.9	4073	162	0.04	12.1	120	8.8	65.3	25.9	30.3	27.6	42.1
1994	5572	39.8%	17.7	4129	166	0.04	12	121	9.8	62.5	27.7	25	28.5	46.5
1995	5749	38.0%	17.5	4184	168	0.04	12	121	8.6	63.5	27.9	28.9	31.6	39.5
1996	5254	40.0%	17.8	4224	179	0.042	11.5	124	6.5	67.1	26.4	26.8	36	37.2
1997	6117	42.3%	17.6	4344	187	0.043	11.4	126	10.1	52.5	37.3	20.7	40	39.3
1998	6477	44.8%	17.8	4282	187	0.044	11.2	126	8.9	58.7	32.4	23	39.8	37.3
1999	6839	44.7%	17.5	4412	197	0.045	11	128	7.7	55.8	36.5	21.4	41.4	37.2
2000	7434	44.9%	17.7	4375	197	0.045	11	128	6.7	55.7	37.5	22.7	42.2	35.1
2001	7189	46.1%	17.6	4462	209	0.047	10.6	131	6.6	47.4	46	17.2	46.3	36.5
2002	7511	47.8%	17.3	4556	219	0.048	10.4	133	6.2	45.1	48.6	17.4	50.5	32.1
2003	7612	47.6%	17.7	4595	220	0.048	10.4	133	6.4	48.1	45.5	17	49.3	33.7

Model Year	Engine		HP/ CID	Drivetrain		Transmission		FI	Fuel Metering			DSL	Four Valve
	CID	HP		FWD	4WD	Manual	Lock		Port	TBI	Carb		
1975	311	142	0.476	0	17.1	37	0	0.1	0	0	99.9	0	0
1976	319	141	0.458	0	22.9	34.8	0	0.1	0	0	99.9	0	0
1977	318	147	0.482	0	23.6	32	0	0.1	0	0	99.9	0	0
1978	314	146	0.481	0	29	32.4	0	0.1	0	0	99.1	0.8	0
1979	298	138	0.486	0	18	35.2	2.1	0.3	0	0	97.9	1.8	0
1980	248	121	0.528	1.4	25	53	24.6	1.7	0	0	94.9	3.5	0
1981	247	119	0.508	1.9	20.1	51.6	31.1	1.1	0	0	93.3	5.6	0
1982	243	120	0.524	1.7	20	45.7	33.2	0.7	0	0	90	9.3	0
1983	231	118	0.543	1.4	25.8	45.9	36.1	0.6	0	0	94.7	4.7	0
1984	224	118	0.557	4.9	31	42.1	35.1	2.6	0	0	95.1	2.3	0
1985	224	124	0.586	7.1	30.6	37.1	42.2	12.3	0	0.2	86.7	1.1	0
1986	211	123	0.621	5.9	30.3	42.7	42	40.5	21.8	18.7	58.7	0.7	0
1987	210	131	0.654	7.4	31.5	39.9	44.8	66.9	33.3	33.6	32.9	0.3	0
1988	227	141	0.65	9	33.3	35.5	53.1	87.7	43.3	44.4	12.1	0.2	0
1989	234	146	0.653	9.9	32	32.7	56.8	93.5	45.9	47.6	6.3	0.2	0
1990	237	151	0.668	15.5	31.3	28.1	67.4	96	55.2	40.8	3.9	0.2	0
1991	228	150	0.681	9.7	35.3	31	67.4	98.2	55	43.2	1.6	0.1	0
1992	234	155	0.685	13.6	31.4	27.3	71.5	98.4	65.9	32.5	1.5	0.1	0
1993	235	162	0.71	15.1	29.5	23.3	75.7	99	73.4	25.7	1	0	0.2
1994	240	166	0.716	13.3	37.4	23.3	75.2	99.6	76.8	22.8	0.4	0	2.5
1995	244	168	0.715	17.7	40.7	20.5	78.6	100	79.8	20.2	0	0	8.1
1996	243	179	0.757	20.1	37.1	15.6	83.5	99.9	99.9	0	0	0.1	10.4
1997	248	187	0.775	13.9	43.3	14.6	84.9	100	100	0	0	0	11.3
1998	242	187	0.795	18.7	42	13.5	86	100	100	0	0	0	15.2
1999	249	197	0.814	17.4	44.6	9.1	90.5	100	100	0	0	0	16.2
2000	242	197	0.832	19.4	42.5	8	91.7	100	100	0	0	0	20.5
2001	243	209	0.882	18.5	43.8	6.3	93.4	100	100	0	0	0	27.1
2002	246	219	0.91	18.3	48	6.4	93.2	100	100	0	0	0	32.2
2003	245	220	0.919	18.1	49.1	5.9	93.3	100	100	0	0	0	33.7

Key for Appendix IV

- Inertia weight – Curb weight + 300 lb.
- 0-60 time – Acceleration from zero to sixty miles per hour (Calculated from formulae, function of weight, horsepower, and transmission type)
- Top Speed – Average top speed (Calculated from formulae)
- Adjusted 55/45 mpg – Combined fuel economy
- CID – Engine Displacement (Cubic Inches)
- Volume – Interior Volume (Cubic Feet)
- DSL – Diesel Engine
- Four valve – Four valves per cylinder
- FWD – Front wheel drive
- 4WD – Four wheel drive
- Manual – Manual transmission
- Lock – Automatic transmission with lockup
- FI – Fuel Injection
- Port – Port fuel injection
- TBI – Throttle Body Injection
- Carb – Carburetor

FINAL REPORT

Contract 02-310
Project No. 008545

Analysis of Auto Industry and Consumer Response to Regulations and Technological Change, and Customization of Consumer Response Models in Support of AB 1493 Rulemaking –

Automaker Response to Passive Restraint Regulation with respect to Actions, Economics, Technology and Marketing

Airbag Case Study for the Analysis of Auto Industry and Consumer Response to Regulations and Technological Change in Support of AB 1493 Rulemaking

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Disclaimer

The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Acknowledgments

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ABSTRACT

This report examines the history of passive-restraint regulation in the U.S. for 1970-2003, with special emphasis on airbag systems. The first passive restraint standard was adopted in 1984, but successfully contested by the automotive industry until 1991 as being too costly. All light duty vehicles sold in the US now must contain a dual frontal airbag system, and the cost has fallen dramatically over time. Automakers have responded to the passive restraint regulation with a variety of pricing, marketing, and financing strategies. The following insights were gained. First, greater regulatory flexibility provides automakers with the opportunity to utilize a greater array of product marketing tools, which leads to lower costs. Second, the cost of complying with passive restraint regulations seems to have had little effect on vehicle sales, both overall as well as across product lines. Third, the nature of the statutory authority and the design of the regulations affected the length of debate, with implications for speed and cost of compliance. Overall, the cost impact of the safety rules on automakers was largely offset by a variety of automaker behaviors and strategies, and eventually by increasing consumer demand for safety.

EXECUTIVE SUMMARY

Background

AB 1493 requires CARB to propose a set of rules that would improve the greenhouse gas emissions of light duty vehicles in California. To provide insight into how future regulations of greenhouse gas emissions might impact automakers and consumers, this case study examined historical federal passive restraint rulemaking. Determining automaker behavior in response to regulation is a difficult task due to the complexity of the market and the guarded nature of industry practices. The first passive restraint standard was passed in 1984, calling for all model year 1990 passenger cars sold in the U.S. to be equipped with a passive restraint system. In 1991, after a long fight between automakers and regulators, legislation was passed that effectively made the passive restraint standard an airbag mandate. Today, all light duty vehicles sold in the U.S. must contain a dual frontal airbag system. This report examines the history of passive-restraint regulation in the U.S. for 1970-2003, with special emphasis on airbag systems.

Findings

The cost of airbag systems fell dramatically as production ramped up and economies of scale were realized. Automakers employed a variety of strategies in meeting the passive restraint regulation. Once airbags were mandated, some automakers rushed to place airbags across their entire vehicle line, while others introduced the technology more gradually. Increased costs to meet airbag regulation had little impact on the volume and mix of vehicle types offered at the time the regulation went into effect. During the period of regulatory debate, automotive industry forecasts tended to overestimate the future cost of airbags, sometimes intentionally by assuming limited production volumes and atypical amortization schedules, while government and advocacy groups often underestimated costs. The prolonged struggle over the federal government's passive restraint regulations resulted in compromised rules and vehicle strategies that had a lower benefit-cost ratio than alternative strategies and rules.

In pricing vehicles, automakers handle the added cost of airbags much as they do other new technologies, and quality improvements generally. Vehicle pricing is a complex process aimed at achieving the corporate objectives of maximizing profit and market share.

Automakers employ a number of strategies to recoup the cost of a new technology such as airbags. In this case, as shown later, auto manufacturers passed most of the added cost of airbags onto consumers, but not necessarily in a straightforward manner. In general, automakers pass costs incurred by regulation through vehicles that are in higher demand and/or have a higher profit margin. Automakers may recoup the cost over a number of years to avoid price shock. Offsetting reductions in standard equipment (decontenting) on some models and a disproportionate raise in dealer (inventory) cost may be used to mitigate the effects of cost pass-through pricing. Such cost recovery behavior will differ somewhat between unregulated in-demand technologies and regulated technologies that consumers do not value.

In this age of creative financing plans and significant financial incentives, including rebates, automakers have an array of marketing tools, in addition to advertising, with which to generate customer demand. In the case of airbags, advertising played a prominent role in educating consumers about the technology and creating demand for this and other safety features. Automakers that pioneered the introduction of airbags (e.g. Mercedes and Chrysler) derived substantial "halo effects" that aided their overall marketing.

Conclusion

Although automakers resisted the passive restraint rules, they eventually responded fully and effectively. They did so in ways that mitigated the economic impact. The initial high cost of airbags was the principal source of concern about the passive restraint standard by automakers. But once airbags were introduced, costs fell dramatically. The safety devices were added across all vehicle segments, with no little or no impact on quantity or mix of sales. Three findings stand out. First, requirements that industry introduce new technologies or products should be made as flexible as possible with appropriate phase-in periods to allow opportunity to utilize the many economic and marketing tools at their disposal. Second, in this case, the cost of compliance may have had some impact for the first year or two after regulation, but the impact on sales across the industry appears to have been negligible. Third, the nature of the statutory authority and the design of the regulations strongly affect the length of debate, which in turn delays the implementation of the rules, and compromises the cost-effectiveness of automaker responses.

1 INTRODUCTION

This report examines automaker behavior in response to passive-restraint regulation roughly from 1970 to 2000. The report consists of the following three sections.

- ***Regulatory Stimulus*** – This section will detail the timeline of the proposed and enacted passive restraint regulation. The installation rate of airbags over the time period of interest will also be presented here.

- ***Industry Response*** – The focus here is the relationship between cost and price. The analysis here first reviews cost and option price information for airbags as reported in media, academic, industry, and government records and sources. An original analysis is also conducted of the costs of integrating an airbag system into a vehicle. The analyses presented here examine automakers *decontenting* to keep prices down when airbags are added. Cost estimates for airbags and airbag components, along with a technology that was not regulated, anti-lock braking systems (ABS) are estimated and evaluated. A discussion follows of the business, job and wealth creation engendered by the nascent airbag industry to further elucidate the economic impact of the regulation. Marketing practices used by the industry to facilitate the adoption of an airbag regulation will be analyzed as well to address how automakers repositioned themselves from their adversarial position toward regulation in order to effectively promote the new safety features.

- ***Consumer Response*** – This section examines the impact of airbags, and the resultant price increase, on vehicle sales. The marketing strategies for promoting more ‘public good’ type attributes related to safety, environment and fuel economy are examined. Other impacts on consumer behavior will also be analyzed.

1.1 Background

The history of Motor Vehicle Safety Standard 208, which governs passenger restraint systems in motor vehicles, is complex. This standard lays the foundation for the repeated governmental attempts at airbag regulation that were finally realized with the inclusion of the airbag mandate in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. The history leading up to this point was filled with avoidance strategies by the auto industry and regulatory compromises that shifted from one presidential administration to another.

The automobile industry in the U.S. was relatively free of government regulation in the 1960s, until mounting concern over air pollution and traffic safety, and later energy use attracted the attention of policymakers. Both the Environmental Protection Agency (EPA), which regulates vehicle emissions, and the National Highway Transportation Safety Administration (NHTSA), which regulates vehicle safety, were established in late 1970 under the Republican administration of President Nixon.

The explicit goal of NHTSA is to "…reduce deaths, injuries and economic losses resulting from motor vehicle crashes. This is accomplished by setting and enforcing safety performance standards for motor vehicles and motor vehicle equipment, and through grants to state and local governments to enable them to conduct effective local highway safety programs."[1] Congress directed that Federal safety standards should be specified in such a manner that "the public is protected against unreasonable risk of crashes occurring as a result of the design, construction, or performance of motor vehicles and is also protected against unreasonable risk of death or injury in the event crashes do occur."[1] The question of which strategy is most effective and desirable – altering driver behavior or improving technology – played a key role in the airbag debate, and continues to underlie debates about how best to improve safety. NHTSA has historically pursued active technology-forcing rules, requiring improvements in auto safety that were ahead of current technology. The courts have supported this approach. For example, the U.S. Court of Appeals upheld the authority of NHTSA to issue an airbag rule in 1972, stating that the agency "is empowered to issue safety standards which require improvements in existing technology or which require the development of new technology, and it is not limited to issuing standards based solely on devices already fully developed."[2]

After years of deliberation, a passive restraint standard was passed in 1984, requiring that 100% of new cars be equipped with airbags starting with the 1990 model year. There were alternative ways to satisfy the standard other than airbags, so even on 1990 model cars, airbag penetration was minimal. This changed in 1991, when the sweeping new transportation bill, the Intermodal Surface Transportation Efficiency Act (ISTEA) included a provision mandating the use of dual airbags on all vehicles sold in the U.S. beginning with the 1998 model year for passenger cars and 1999 for light trucks.

By 2003, over 117 million (54.6%) of the more than 216 million cars and light trucks on U.S. roads were equipped with dual airbags. Another 21 million vehicles had only a driver-side airbag. NHTSA has estimated that as of August 2003 12,776 people are alive today because of an airbag.

1.2 RESEARCH APPROACH

The regulatory history of passive restraint standards is well documented in government sources, the media, and the scholarly literature; but the costs of complying with the rules, and how industry and consumers responded to the rules and technologies is not well understood.

Methods

The following analysis employs a case study approach, which is a form of qualitative descriptive research. While case studies are by definition context-specific, and as research, do not exhibit generalizability, automaker behavior in response to this specific regulation can in many ways be considered indicative of such conduct toward regulation overall. As a result, the emphasis of the paper will be on exploration and description, addressing questions of who, what, where, how much, and how many.

Many studies used average estimated costs of airbags, but these numbers are highly uncertain and disparate. Industry, government and lobby groups generated a wide range of cost estimates over the years that used widely varying assumptions and methods. A number of NHTSA-sponsored teardown economic analyses of real airbag systems in the late 1980s and 1990s are the most reliable sources for cost information. We contacted a number of airbag suppliers and two OEMs to elicit cost and pricing information, but they were unwilling or unable to provide authoritative data.

The first step in this airbag case study is a brief overview of the regulatory history and a description of the penetration rates of the technology after the standard was enacted. We then analyze industry response by first detailing costs and prices for airbag components and systems as reported in mass media, academic, industry, and government records and sources, including an original analysis of the cost of integrating airbag systems into a vehicle. A wide variety of industry responses to these safety regulations were examined, including *decontenting* (making standard features such as air conditioning or anti-lock brakes optional), pricing and marketing practices, and advertising. The response of consumers to these new technologies was also examined in terms of prices, passenger car sales, and the public and private good nature of the new technologies. In addition, parallels and contrasts with other regulations such as emissions standards were identified, and an attempt was made to ascertain areas where lessons learned from the passive restraint standard record could be applied to future government actions with respect to greenhouse gas (GHG) emissions.

2 HISTORY OF PASSIVE RESTRAINT REQUIREMENTS

…the automobile industry waged the regulatory equivalent of war against the airbag and lost.[3]

-The Supreme Court, 1983

While the legislative discussion of passive restraints began as early as the 1960s, it took many years before the first rules and laws were passed. Throughout the public debate that took place in the media and in Congressional hearings, the focal technology of the pending regulation never wavered. The focus was the airbag. The auto industry consistently diverted attention away from airbags in favor of competing technologies thought to be much less costly to implement. Meanwhile, the NHTSA-Insurance coalition touted airbags throughout, but had difficulty fully allaying the concern of Congressmen and others about the cost, safety and public acceptance of airbags. Hence it was not just an issue of cost, but rather a small array of factors that delayed the adoption of the regulation.

2.1 FMVSS 208 DEVELOPS INTO AN AIRBAG MANDATE

NHTSA was committed to making the passive restraint regulation a performance standard that could be met with different technologies. The agency retained this principle throughout the period of time leading up to the regulation, but then along with Congress discarded it when an airbag mandate was passed in 1991. After airbags were designated as the only available technology suitable for passive restraints, the regulation still had the characteristics of a performance standard. This meant that the criterion for an acceptable airbag system was based on crashing vehicle platforms with dummies at a certain speed into a fixed barrier.

2.1.1 The Passive Restraint Requirement Issued By Secretary Dole

On July 11 1984, Secretary Dole announced a passive restraint requirement to be phased in starting with the 1987 model year. Under the new rule, auto manufacturers could satisfy the standard "by using automatic detachable or nondetachable belts, airbags, passive interiors, or other systems that will provide the necessary level of relief."[4] Anticipating that most automakers would opt for the less expensive option, namely automatic safety belts, the rule provided incentives for new technologies by giving a 50% additional credit for each car equipped with either airbags or a soft interior system developed by GM. But Dole also declined to agree with the notion that automakers would necessarily choose the cheapest way out. Dole stated that "the Department does not agree with this contention. It believes that competition, potential liability for any deficient systems, and pride in one's product would prevent this." By extending this logic, automakers would forgo cheaper, potentially less safe restraint systems in favor of safer alternatives - such as the one the agency identified as the safest alternative of all: "An airbag plus a lap and shoulder belt."

Secretary Dole allowed an escape route from the regulation for the automakers if states comprising two-thirds of the U.S. population were to pass mandatory seat belt usage laws before April 1, 1989. The law would subsequently be rescinded if this threshold were met. Partly in response to the U.S. Supreme Court's finding that her predecessor's decision to rescind the standard was "arbitrary and capricious" for its failure to consider an "airbag specific" requirement, Secretary Dole responded as follows:

- First, comparing the two, she said that "[a]lthough airbags may provide greater safety benefits, when used with belts, and potentially larger injury premium reductions than automatic belts, they are unlikely to be as cost effective."
- Second, Secretary Dole expressed concern that, due to public unfamiliarity with the technology, a government-mandated "airbags only" rule "could lead to a backlash affecting the acceptability of airbags."
- Third, Secretary Dole noted that several commenters "questioned the Department's authority to issue an 'airbags only' standard, claiming that it would be a 'design' standard." She said that, "[e]ven if the Department could legally issue a performance standard that could only be met by an airbag under present technology," doing so would create "a number of problems" and could "unnecessarily stifle innovation" in other types of passive systems, such as automatic belts and passive interiors.

The phase-in schedule was set as follows:

- Ten percent of all automobiles manufactured after September 1, 1986 (1987 model year).
- Twenty-five percent of model year 1988 automobiles.
- Forty percent of model year 1989 automobiles.
- One-hundred percent of model year 1990 automobiles.

2.1.2 The Intermodal Surface Transportation Efficiency Act of 1991

On December 18, 1991, President Bush signed the Intermodal Surface Transportation Efficiency Act of 1991. Buried deep in the bill, which allocated $155 billion to various transportation activities over six years, was a requirement that all automobiles and light trucks sold in the U.S. must be equipped with airbags. It required that:

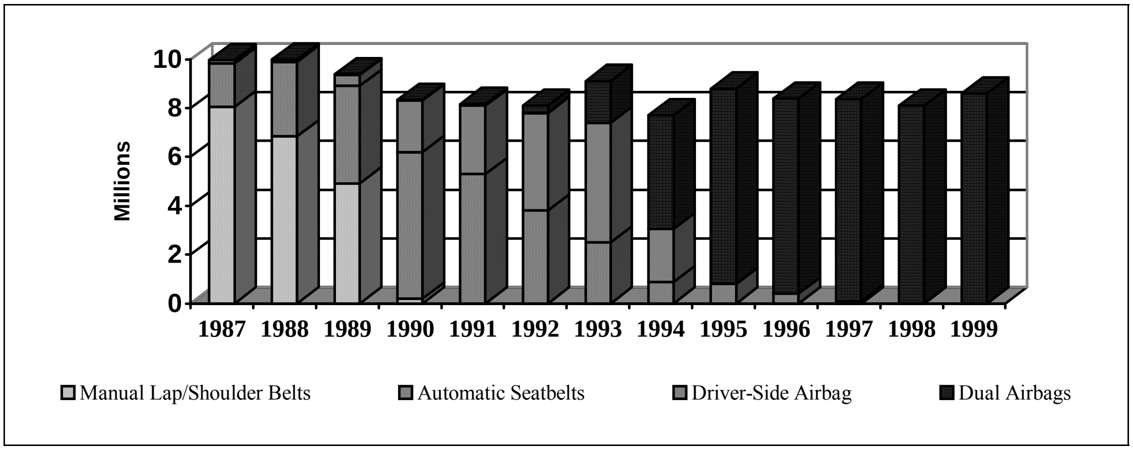
> *At least 95 percent of each manufacturer's passenger cars manufactured on or after September 1, 1996 and before September 1, 1997 must be equipped with an air bag and a manual lap/shoulder belt at both the driver's and right front passenger's seating position. Every passenger car manufactured on or after September 1, 1997 must be so equipped.*
>
> *At least 80 percent of each manufacturer's light trucks manufactured on or after September 1, 1997 and before September 1, 1998 must be equipped with an air bag and a manual lap/shoulder belt. Manufacturers may count towards compliance with the 80 percent requirement those light trucks it produces that are equipped with an air bag and manual lap/shoulder belt at the driver's position and a dynamically-tested manual lap/shoulder belt at the right front passenger's position.*
>
> *Every light truck manufactured on or after September 1, 1998 must be equipped with an air bag and a manual lap/shoulder belt at both the driver's and right front passenger's seating positions. Multistage light trucks are required to comply with the same requirements that apply to comparable single stage light trucks.*[5]

The twenty-year debate came to a close with this act of Congress. Indeed, the widespread introduction of airbags was virtually a foregone conclusion at this point due to the rising acceptance of airbags in the marketplace.

2.2 PENETRATION RATES FOR AIRBAGS

In 1984 Mercedes-Benz was the first automaker to offer optional airbags on passenger cars since GM's brief and ultimately unsuccessful flirtation with the airbag during the 1974-76 model years. Other automakers adopted a wait-and-see approach to airbags due to uncertainty over how consumers would respond to the safety devices. Figure 2-1 displays the automaker incorporation of passive restraint technologies in cars (excluding light duty trucks).

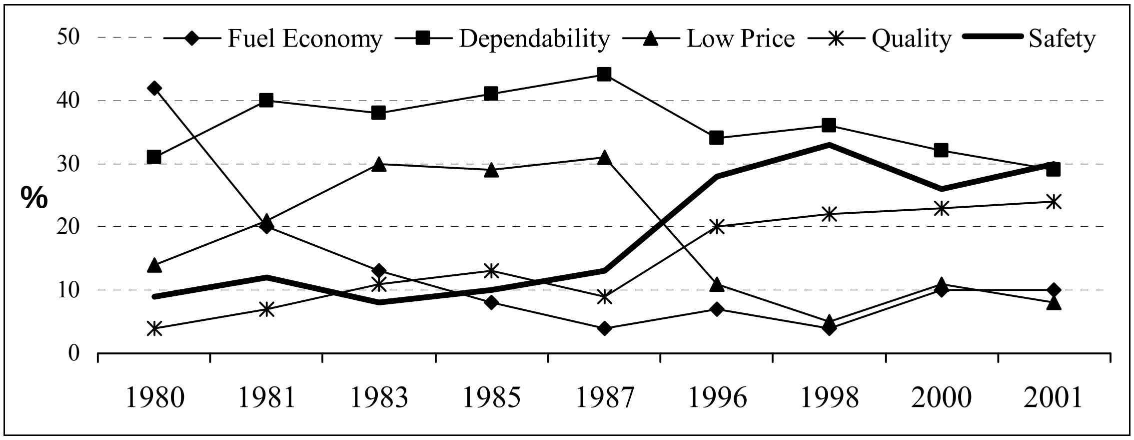
Figure 2-1 Annual U.S. New Passenger Car Sales by Occupant Restraint System



Source: Ward's Automotive Yearbook, Automotive News Market Databook – Various Years

By the 1990 model year, a full-fledged airbag race had emerged. The Big Three Detroit automakers quickly ramped up production – from selling a little over 400,000 airbag-equipped vehicles in 1989 to nearly two million in 1990. Chrysler, and to a lesser extent Ford, provided much of the impetus behind the move toward airbags. GM followed its two smaller rivals. GM President Robert Stempel expressed concern over the cost of airbags and how these costs would be passed on to the customer, along with the yet unproven consumer acceptance of the safety devices.[6] European automakers, who tended to sell more high-end cars in the US market, were also well out in front with airbags. Asian automakers, except for luxury models, had taken the less expensive path and embraced automatic seat belts instead of airbags. It has been hypothesized that the domestic automakers adopted the technology relatively quickly in 1990 because the American firms saw it as a way to positively differentiate themselves from Japanese automakers.[7] The Japanese soon responded. During the 1990 model year, domestic automakers offered airbags in one-third of their cars sold in the U.S., while Japanese manufacturers had them in only 6% of their vehicles. In the 1992 model year 54% of Japanese cars sold in US had airbags compared to 49.5% of U.S. cars.[8]

Figure 2-2 History of Consumer Valuation of Vehicle Attributes



Sources: For 1980s: J. D. Power (data based on new car buyers). For 1996+: Opinion Research Corporation International (ORCI) for National Renewable Energy Laboratory (NREL), Studies # 707089, 709318, & 710288.

As previously mentioned, the race to install airbags was to a great extent forced by regulation, but a shift in car buyer's valuations of vehicle attributes was also an important motivation. Figure 2-2 illustrates the ascendancy of safety concerns from the 1980s when it was the most highly valued attribute for less than ten percent of consumers, to the 1990s when it was rated number one by roughly one-third of the consumers polled. The arrows of causation for the rapid introduction of airbags and the dramatic rise in concern for vehicle safety went both ways. Airbags benefited from consumers new found awareness of safety. By the early 1990s, airbags even became a metric of vehicle safety. The presence of airbags in vehicles, dealer's showrooms, and the media, heightened the car shopper's interest in safety.

Figure 2-3 Driver-Side Airbag Installation Rates in US Passenger Cars by Automaker Region

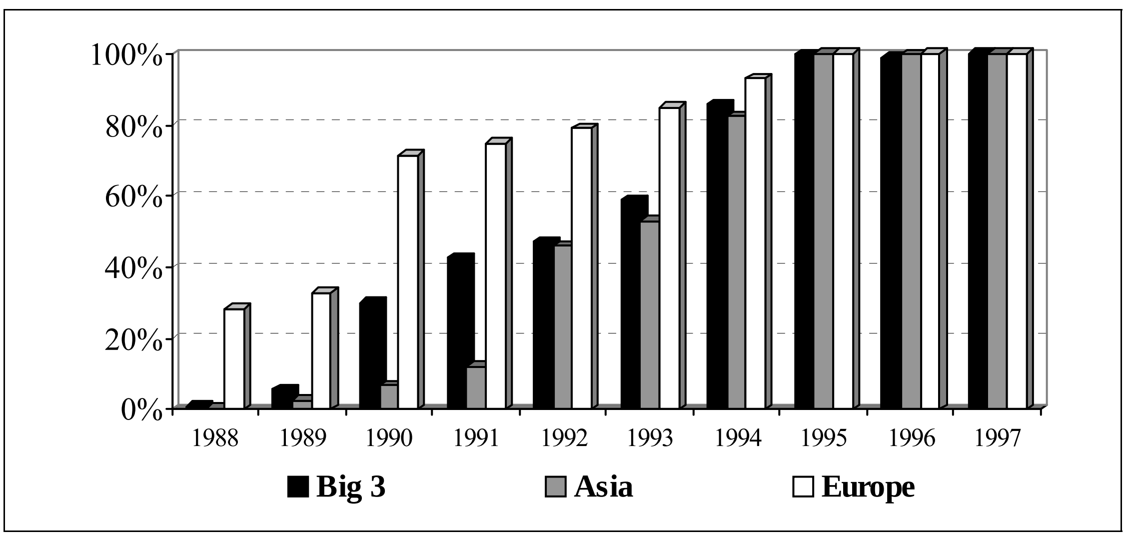
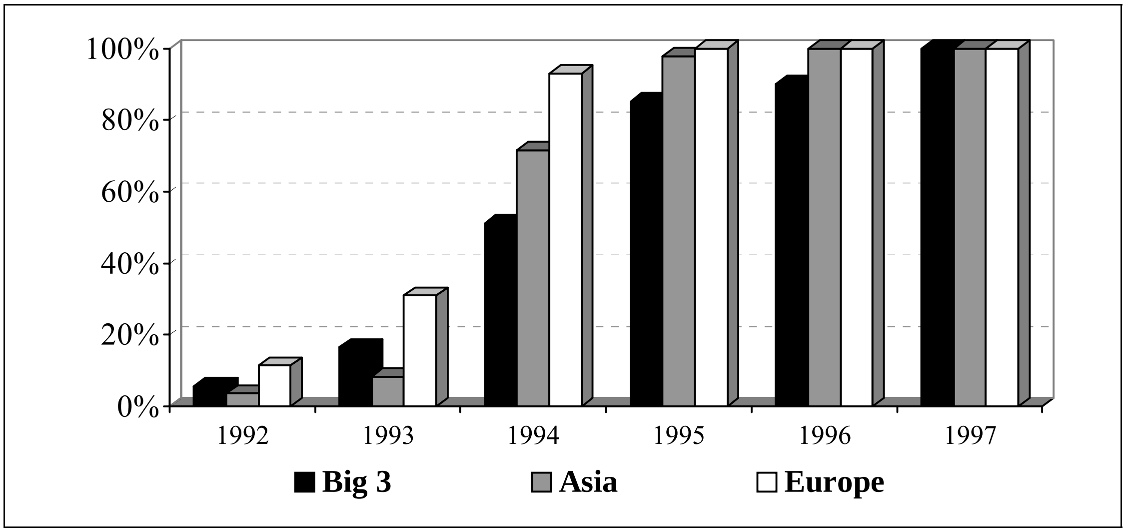


Figure Notes: 1**. Big 3** is GM, Ford, and Chrysler 2. **Asia** is Toyota Group, Honda Group, Nissan Group, Mazda, Subaru, Mitsubishi,. and Hyundai 3. **Europe** consists of Volkswagen, Audi, Mercedes-Benz, BMW, Volvo, and Saab. **Source:** Ward's Automotive Yearbook (Various Years)

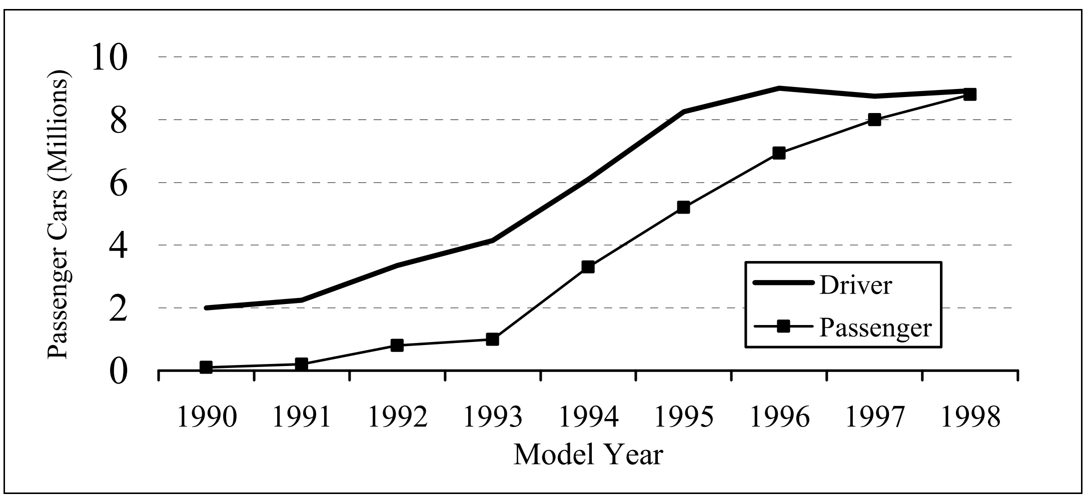
Figure 2-4 Passenger-Side Airbag Installation Rates in US Passenger Cars by Automaker Region



Source: Ward's Automotive Yearbook (Various Years)

Figures 2-3, 2-4, and 2-5 show in greater detail the installation rates of driver and passenger airbags over the time period of interest. Automakers responded quickly to the regulation, particularly in the case of passenger airbags. Due to the flexibility of the phase-in schedule, automakers were able to introduce the safety devices into their vehicle lines in ways that made the most sense for each automaker.

Figure 2-5 Number of Airbag Units Installed on Passenger Cars Sold in the US



Source: Ward's Automotive Yearbook (Various Years)

3 INDUSTRY RESPONSE

The prospective regulation of airbags became a heated debate that pitted automakers and their sympathizers on one side, and the NHTSA, insurance companies and various safety proponent groups and individuals on the other. One of the recurring and most successful arguments put forth against the adoption of airbag regulation concerned the added cost that would be incurred by the automobile manufacturers, and the inability of the market to support that cost. Automakers claimed that NHTSA offered highly optimistic, and in some cases, unrealistic cost estimates for the airbag system. Meanwhile, government and safety proponents argued that carmakers inflated the true cost of the systems in order to strengthen their case against airbags. Complicating matters was the variability in airbag system complexity and modular construction among the various carmakers and automotive suppliers. Varying amortization schedules and projected production volumes added yet more layers of complication.

Here we compile, interpret and present the wide range of cost estimates that were presented in the media, Congressional hearings, and other documents. Retrospectively, we analyze the added cost of airbags to manufacturers and buyers, and explore whether this cost differential was markedly dissimilar to typical annual changes in vehicle prices. As part of this analysis, we estimate experience (cost) curves for airbags and airbag components. We also look at automotive safety technologies that were not regulated, specifically anti-lock braking systems (ABS), traction control, and side airbags.

3.1 Barriers to Airbag Adoption from an Automaker Perspective

There were a number of obstacles that conspired against the swift adoption of a passive restraint standard. This explains the drawn-out character of the passive restraint regulation.

3.1.1 Cost

Cost is a central theme in this report just as it was in the drawn-out debate over passive restraint regulation. Issues dealing with cost and pricing will be addressed at great length later in this section. The automakers' argument based on cost stemmed from other arguments that could be made against airbags. If airbags were a considerably more expensive possibility for meeting the passive restraint standard, then automakers would choose the lower cost option, which in turn would make any airbags that were introduced more costly. This circular relationship provided a strong case against airbags. NHTSA could have eliminated much of the cost argument by mandating airbags exclusively. The large cost associated with replacing a deployed airbag was also a deterrent. Questions were raised whether a car may have to be declared totally destroyed in a minor collision because the replacement cost of the airbag is higher than the car's value.[9] Auto insurers were universally in favor of airbags, which indicates insurance plans would address these and other concerns.

3.1.2 Product Liability Claims

The legal complexities rooted in the liability concerns of automakers are beyond the scope of this report. A number of lawsuits were filed, particularly after 1990, involving accidents resulting in severe injury or death where the vehicle was not equipped with an airbag. These lawsuits claimed that automakers possessed both airbag technology and the knowledge of its life-saving potential, but chose not to install the technology. These so-called 'no-airbag' lawsuits resulted in settlements in many lower courts, but were not upheld upon appeal when the Supreme Court settled the issue in 2000. Such liability claims were a concern to automakers, but greater concern was given to product liability claims stemming from a possible inadvertent deployment, failed deployment, or injurious deployment in a moderate collision.

3.1.3 Less Expensive Alternatives

As described above, automakers were granted flexibility when complying with the passive restraint standard. Experience from the first (and failed) attempt at a passive restraint standard during the early 1970s may have helped inform the more successful regulatory process that came in the following decade. In 1970 Ford Motor Company petitioned the National Highway Safety Bureau (NHSB), predecessor agency to NHTSA, to allow ignition interlock devices, which would prevent the vehicle from being started unless the seatbelt were fastened, in lieu of airbags. Ford argued that seat belt usage could be bumped up to acceptable levels if "a more sophisticated ignition interlock system, exterior warning device, etc., [could] be developed."[10] An interlock system on all new vehicles for the 1974 model year was included in the pending regulation, but once the technology appeared in cars, consumers flatly rejected it, often by disconnecting the wires, rendering the system ineffective. The House of Representatives soon voted by a large margin to render the regulation requiring the device (or airbags) null and void.[11]

The history of automatic seatbelts during the late 1980s and early 1990s was similar to that of the interlock device. The unpopularity and awkward functionality of the automatic seat belt may have benefited airbags. For some consumers the impetus behind purchasing an airbag-equipped car may not have been, "I want an airbag," but rather, "I don't want automatic seat belts." But it was becoming apparent that the industry was moving toward airbags and away from the unpopular belts. Automatic seat belts were also considered dangerous because occupants could be lulled into a false sense of security and fail to buckle their lap belt thus making the safety system potentially more dangerous than no seat belt at all. As a result, it was reported in mid-1991 that automakers would phase out the automatic belts over the course of the next few years prompting the president of the Insurance Institute of Highway Safety (IIHS) to say, "in a few years automatic seat belts are going to be like dinosaurs."[12] The head of NHTSA since 1989, Jerry Curry, acknowledged in August 1991 that with the information on crashes that was then available, airbags combined with seatbelts should have been mandated exclusively.[13] The timing of this recognition of regulatory failure, which pointed out the inferiority of automatic seatbelts, was curious because the belts were still being installed in the millions despite the broad aversion consumers developed toward the intrusive devices. The automatic seatbelts were quickly becoming the bête-noir of passive restraint options, while airbags were being met with unexpected acceptance.

Standard 208, which includes occupant crash protection, was written to be a performance-based regulation that would not specify one particular technology in a mandate. This loophole left open the opportunity for automakers to seek out and develop alternative passive restraint technologies that would meet the crash test criteria at a lower cost than airbags. The automakers indeed did develop two competing technologies, ignition interlock and automatic seat belts, but they were inferior to airbags, according to crash tests, and provided no added protection above and beyond a lap and shoulder belt. Instead, the ignition interlock and automatic safety belts would in theory simply force the occupant to wear this pre-existing protection. Consumers ultimately and emphatically rejected the entire premise these safety devices were based upon. As a result, it ended up being a more costly and circuitous road to equipping cars with airbags than it may otherwise have been if the regulations were more strongly written and implemented, and if carmakers were more cooperative. Both the policymakers and the auto industry made the pathway to airbags more circuitous than was necessary.

A possible alternative to a passive restraint standard altogether was a seatbelt law. Passive restraints were deemed necessary in the first place because of the low usage rate of existing seatbelt systems. One irony is that airbags are truly effective only if seatbelts are also worn. Another irony is that automakers opposed regulation that would make seatbelts mandatory because it would ruin the styling of their vehicles and reduce sales.[14] Automakers pushed for a regulation that would provoke behavioral changes, namely 'buckling up', while NHTSA regulators and their supporters insisted that passive restraints were also needed. As of today, we have both types of laws. Dual airbags are of course mandatory on all new vehicles sold in the U.S., and 49 states have mandatory seatbelt use laws, 18 of which are *primary* laws allowing police to treat a seatbelt violation as a standard traffic violation.[15] A spokesperson for Ford Motor Co.

articulated the position of the auto industry on the matter at the time: “the decision to force the substitution of unproven “automatic protection” devices for proven, reliable, and effective active safety restraint systems is so fraught with error as to be both lacking in rational basis and unsupported by substantial evidence in the rulemaking record.”[16] Automakers as a sign of solidarity banded together to support seatbelt usage laws and informational campaigns to construct a meaningful alternative to passive restraints.

3.1.4 Questions about Airbag Reliability and Performance

Airbags are unique among automotive systems. Brakes, for example, can be disassembled for inspection or maintenance, and can provide the driver feedback regarding their condition when the brakes are used. Airbag systems may remain unused for long periods of time, but must effectively deploy in milliseconds when a frontal crash occurs. The fears surrounding airbags during the regulatory debate were not only that the airbag would not deploy properly in the event of a crash, but also that it may deploy unnecessarily during normal driving conditions. Despite the successful de facto field tests done by State Farm and the owners of airbag-equipped GM cars, questions concerning the reliability of airbags across an entire fleet of vehicles continued to be raised.

3.1.5 Airbag Regulation was viewed as Beatable by Automakers

Of the three main automotive regulatory initiatives at the time – fuel economy, emissions, and safety – the airbag may have been viewed as the least tenable. While all of these potential regulations were perceived as imposing significant cost, airbags had a number of other strong arguments against them. Product liability concerns, uncertainty about replacement costs, and lobbying for reasonable alternatives all worked against a speedy adoption of an airbag standard. On a more fundamental level, the nature of performance standards created problems in the safety area that were absent from fuel economy or emissions. Any flexibility created for emissions and CAFE standards did not impair the chances of a preferred technology as in the airbag case. The following passage helps explain why automakers chose to fight aggressively against NHTSA.

> *They (automakers) wanted relief from environmental requirements too, but they knew that was impossible. They had already talked to William Ruckelshaus at the Environmental Protection Agency (EPA) and had been given a lesson in statutorily mandated regulation. The Congress had put EPA emission control criteria under a strict statutory timetable that neither agency nor industry could evade for long. Under that statute manufacturers might get a year’s relief, but only if they could demonstrate their own failure in good faith effort at compliance.*[1]

Once automakers were granted a significant delay in meeting the passive restraint regulation the first time, the difficulty NHTSA experienced in enacting the regulation intensified.

3.2 COMPLIANCE COST

3.2.1 Reported Airbag Cost Estimates 1969 – 2000

A large number of airbag cost estimates were produced during and after the time of deliberation. Most of these were conducted before airbags were mass produced. All suffer some shortcoming, often related to the interests of the sponsor or analyst. The studies are confounded by asymmetric information. Industry groups that face potential regulation generally have better information about the nature of compliance strategies than regulatory agencies and advocacy groups. Industry cost estimates are often susceptible to being too high, especially when firms do not fully anticipate cost-saving measures they may discover once company efforts are directed toward compliance. Indeed, regulation can trigger innovation that can offset some or all of the compliance costs.[17] When companies are opposed to regulations, they will tend to be pessimistic about cost improvements.

Similarly, government and safety advocacy groups tend to be optimistic about cost improvements. Whether the bias in the opposite direction is equal in magnitude is unclear. NHTSA did forecast the future costs of airbags with a reasonable degree of accuracy, and tended to overestimate the benefits of airbags (i.e. lives saved and injuries reduced) to a greater extent than the cost reductions of airbags. At least one study argues that government agencies tend to overestimate compliance costs more often than they undervalue these costs.[18] This study states that most regulatory cost estimates ignore the possibility of technological innovation mainly because it is difficult to predict. Technical change tends to defy accurate forecasting, and based on historical experience, the only thing that is certain is the cost of compliance will likely decline, but at what rate is anybody's guess. NHTSA employed thorough analyses based on available data to arrive at reasonable forecasts that were more or less validated by what eventually transpired.

This airbag case study does uncover some discrepancies in cost estimation over the years and across the government and industry groups. NHTSA relied on cost information from airbag suppliers and from its own teardown studies, which lead to fairly reliable results. The complexity in estimating the costs of airbag technology is due to the large economies achieved with mass versus limited production, and the progress achieved in reducing the cost of airbag inflators and other components once a market was assured by regulation. Despite these uncertainties, NHTSA made reasonably accurate cost estimates, as did the industry given their tendency to use unfavorable assumptions of production volume and amortization schedules. Once passive restraint regulation became an airbag mandate, the cost estimation process was simplified considerably because Congress made the regulation a design standard by requiring airbag technology to be the sole compliance strategy. The economic complications associated with predicting firm-by-firm compliance with a performance standard were thereby removed, though the flexibility benefits of a performance standard were also removed. If policymakers had insisted on airbag technology as the only suitable means to meet the standard from the beginning, both cost estimates and actual costs would have been lower due to higher production runs, a steeper learning curve, and a higher concentration of innovative energy that focused exclusively on airbag technology. In many instances a performance standard leads to the optimal means of compliance, but in the case of airbags, a performance standard allowed automakers to explore avenues of compliance that were later found out to be unacceptable, or poor substitutes for airbag technology.

Post-regulation history has validated both the approach NHTSA took and the estimates the agency generated. Aside from the furor that arose in response to inadvertent deaths mostly of smaller women, children and infants caused by airbag deployment in low-speed crashes, the seven year or so transition to a 100% airbag-equipped vehicle fleet went off without a hitch. In retrospect, the cost estimates generated by government, airbag supplier and insurance sources have been shown to be more accurate and realistic than OEM projections. Table 3-1 summarizes the wide range of estimates that appeared between 1976 and 1982 when the debate surrounding airbags and passive restraints raged most intensely. The estimates produced by John DeLorean, a GM Executive turned private consultant, were formulated using GM's typical cost-figuring method.[19] DeLorean argued that GM was using an unusual method for determining cost because the company was opposed to the regulation. DeLorean's 1976 estimate range of $241-$298 in 2002 dollars was in line with DOT estimates and was lower than some pro-regulation insurance industry sources (e.g. AIA and Nationwide) at the time. As shown in Table 3-2, the markup to arrive at consumer cost is between 2.6 and 2.8 times manufacturer cost for Ford and GM systems. These results were made public from confidential sources by the Center for Auto Safety. The great disparity between costs associated with low and high production volumes can be seen in Table 3-1. Low production volumes were allowed to be considered for automakers such as GM and Ford that sold well over a million vehicles per year because any pending passive restraint regulation could be met by the much less expensive option of automatic seatbelts. This led to consumer cost estimates well in excess of $1,000 (2002 $) for a driver side airbag. If the regulation called exclusively for airbags, high production runs would be implicitly built into the assumptions behind the cost formulation. Moreover, since airbag suppliers would be providing airbag systems in large quantities, the smaller OEMs would benefit from the large price reductions that would result from the large economies of scale.

Table 3-1 Reported Non- Proprietary Airbag Consumer Price Estimates

Year	Source of Estimation	Production Run (if specified)	Airbag Price Estimate ($1982)	Airbag Price Estimate ($2002)
1976	Chrysler		$449	$800
	Ford		$431	$768
	GM		$329	$586
	DeLorean1		$167	$298
	AMC		$449	$800
	Toyota		$644	$1,148
	Amer. Insur. Assoc.		$374	$667
	Nationwide Insurance		$192	$342
	Allstate		$150	$267
	DOT1		$186	$332
	DeLorean2		$135	$241
	DOT2		$150	$267
	DOT3		$145	$258
1977	GM	3.5 Million	$273	$487
	Ford		$332	$592
	DOT		$158	$282
	Chrysler		$368	$656
78	Ford (Letter 1979)		$353	$629
	NHTSA (Letter 1979)		$263	$469
1981	BMW		$1,040	$1,854
	Ford		$832	$1,483
	NHTSA (Jaguar)		$416 - $1144	$742 - $2039
	Chrysler		$1,040	$1,854
	Renault		15 – 20% Car Price	- - - - -
	GM	100,000	$1,144	$2,039
	DOT1	1 Million	$196	$349
	DOT2	1 Million (Dual)	$343	$611
	Talley1	10,000 (3 airbags)	$1,247	$2,223
	Talley2	500,000	$291	$519
	GM	400,000	$676 - $728	$1,205 - $1,298
	Ford	200,000	$858	$1,529
	Talley & NHTSA	100% installation	$208 - $312	$371 - $556
	Talley3	2 Million	$220	$392
	Center for Auto Safety		$208	$371
1982	Ford (U.S. GAO)	Near 100% Install	$235	$419
	Ford (U.S. GAO)	787,000	$575	$1,025
	Ford (U.S. GAO)	200,000	$828	$1,476
	NHTSA (U.S. GAO)	Near 100% Install	$112	$200
	GM (U.S. GAO)	Near 100% Install	$193	$344
	GM (U.S. GAO)	750,000	$509	$907
	GM (U.S. GAO)	400,000	$581	$1,036
	Automobile Occupant Protection Association (AOPA)	10,000	$1,100	$1,958
	AOPA	100,000	$500	$890
	AOPA	500,000	$280	$498
	AOPA	1,000,000	$240	$427
	AOPA	2,000,000	$185	$329
	Average Auto Industry		**$579**	**$1,032**
	Average NHTSA, Insurance,	**Etc…**	**$266**	**$474**

Source: All Sources Listed in the Bibliography of Data Sources

In Table 3-2 a number of cost estimates generated by GM and Ford are presented. The consumer cost indicates the retail price of an installed airbag system, while the manufacturer's cost is the cost incurred by the automakers for one complete airbag system based upon a specified production volume. The manufacturer's cost was confidential before Clarence Ditlow of Center for Auto Safety released the internal DOT memorandum to the press in 1979. The markup method used to arrive at the consumer cost is not specified, but is higher than typical markup factors. For example, NHTSA uses a typical markup factor of (1.33*1.51), or about 2, in its teardown studies. In 1982, GM sold 3,491,630 passenger cars in the U.S., and Ford Motor Co. sold 1,345,970 cars. GM and Ford had high enough production volumes to achieve the much lower costs reported in Table 3-2.

Table 3-2 NHTSA Estimate of Airbag Costs

System	Volume	Estimator	Date	Consumer Cost	Manuf. Cost	Ratio Consum. Cost to Manuf. Economics
GM 82	400,000	GM	3/79	$581	***$221***	2.6 (1979)
GM 82	750,000	GM	3/79	$509	***$195***	2.6 (1979)
Ford 82	885,000	Ford	8/78	$268	***$101***	2.7 (1976)
Ford 82	787,000	Ford	7/79	$575	***$213***	2.7 (1982)
Ford 82	200,000	Ford	7/79	$825	***$300***	2.8 (1982)
GM 80's	3,500,000	GM	11/78	***$206***	***$96***	2.1 (1982)
GM 73 Buick	100,000	DeLorean	10/78	$192	NA	NA

Source: Internal DOT Memo, Subject: Outrageous Air Bag Costs. From Director of Office of Vehicle Safety Standards, A.C. Malliaris to Associate Administrator for Rulemaking, Michael Finkelstein, 11 July 1979. Received from Clarence Ditlow, Center for Auto Safety, September 2003.

Table 3-3 Consumer Costs (RPEs) of Airbag Systems from Three NHTSA Contracted Studies

YEAR	VEHICLE	PRODUCTION RUN	AIRBAG PRICE ESTIMATE (CURRENT $)	AIRBAG PRICE ESTIMATE (2002 $)
Khadilka[20] (1988)	Mercedes 190E[1]	150,000	$443	$670
	Mercedes 190E[1]	350,000	$325	$492
	Mercedes 190E[2]	350,000	$352	$533
	Mercedes 190E[3]	350,000	$380	$575
	Ford Tempo[1]	25,000	$815	$1,233
	Ford Tempo[1]	350,000	$258	$390
	Ford Tempo[2]	350,000	$286	$433
	Ford Tempo[3]	350,000	$308	$466
Fladmark, et al.[21] (1992)	Ford Crown Victoria[4]	300,000	$332	$417
	Acura Legend[4]	300,000	$486	$610
	Toyota Camry[1]	300,000	$308	$387
	Buick Roadmaster[1]	300,000	$307	$385
	Plymouth Acclaim[1]	300,000	$226	$284
	Chevrolet Camaro[1]	300,000	$278	$349
Spinney, et al.[22] (2000)	Chrysler Cirrus/Stratus	250,000	$354	$370
	BMW 5-Series[5]	250,000	$730	$763
	BMW Z3	250,000	$362	$378
	Ford Taurus	250,000	$372	$389

1 – Driver-Side Airbag (No Auto Seatbelts) 2 – Driver-Side Airbag w/ Auto Seatbelts
3 – Dual Airbags w/ Auto Seatbelts 4 – All are dual airbag systems + seatbelts 5 – System includes Side Airbags and Head/Curtain Airbags

Table 3-3 summarizes the cost estimates derived from three DOT contracted teardown studies that use NHTSA's standard methodology. The considerations taken are outlined in Appendix F. The Ford Tempo and Mercedes 190E estimates show costs at two different production runs. The retail price estimate of the airbag system for a Tempo produced at 350,000 units is less than one-third of the price when only 25,000 units are produced. The economies of scale for the 190E are not as great, presumably because much of the scale effect had already been achieved at 150,000 units. A standard cost-cutting measure of automakers involves optimizing production overlap and benefiting from economies of scale in their operations. A detailed discussion deriving from the cost estimates shown in Table 3-3 will be offered in section 3.3.1.

3.2.2 Option Pricing of Airbags

Once airbag installation really took off around 1990, the safety devices were almost exclusively offered as standard features. Also as the passive restraint regulation segued into an airbag mandate during the same time period, automakers felt a sense of urgency to introduce airbags into their entire lineup of cars as quickly as possible. Consumer demand also accelerated rapidly at the same time further fueling the airbag race. Analyzing how automakers priced the airbag as an option will help to paint a complete cost picture, even though airbags were offered only selectively as options. Anti-lock braking systems (ABS) were by comparison presented more as optional equipment because there was no mandate forcing the component's installation. The option pricing of airbags also tended to be well above cost because airbags were fast becoming a desirable attribute.

GM was far in front of the competition when it first offered optional dual airbags on a number of its full-size models during model years 1974 and 1976. GM offered the airbag option on a number of Cadillacs, Oldsmobiles and Buicks. During the three years, the company sold a little over 10,000 of these airbag-equipped cars, although the company had tooled up to produce in excess of 100,000 such vehicles, and had initially expected sales of 300,000 or more.[23] The dealers partly blamed the $225 to $315 price tag for the poor sales of the safety option as being prohibitively expensive for most car buyers. John Delorean, a GM executive turned private consultant argued that if GM had employed its typical cost-figuring method, the airbag option would have been priced at about $100.[19] Of course, at the small number of airbags that were actually produced, GM was selling each option at a substantial loss. The failure of regulators to enact a passive restraint standard that would support GM's attempts at introducing airbags into its vehicles, which at the time comprised 40% of the overall market, contributed significantly to the collapse of the GM airbag program. Regulators sent and continued to send mixed signals to the automakers, and set in motion a tendency toward stagnating compromise and delay that continued until airbag regulation was finally passed. On the other hand, GM abandoned the program quickly and did not get behind it with its full marketing muscle. These issues will be examined in a further section that explores the marketing of the airbag and safety.

Volvo publicized that it would offer driver-side airbags as an option on some of its 1983 model year cars, but the plan to do so never materialized. The retail price for these systems was expected to be $900 to $1000 per car.[24] Apparently undaunted by GM's rather disastrous attempt at selling the airbag, Mercedes-Benz announced in January 1983 that the company would offer optional driver-side airbags at an additional price of $800 to $900 per car on some of its 1984 models.[25] As described earlier, a number of observers that had followed the airbag regulation closely were sharply critical of the way GM marketed the airbag as an option in the mid-1970s. Perhaps learning from

GM's experience, Mercedes made the airbag a focal point of the company's safety-oriented advertising campaign. By 1989, it was reported that Mercedes was making money on its airbag system, which at that point had become standard on all of the company's models sold in the U.S.[26]

Ford Motor Co. was the next auto company to take the airbag plunge, in the 1987 model year. Interestingly, Ford offered an optional driver-side airbag on one of its least expensive models – the Tempo and its sister model, the Mercury Topaz. The price of the airbag alone was between $622 and $815, but the safety device was also included in two of Ford's preferred optional equipment packages at a cost of about $300. The airbag was grouped with other options, namely automatic transaxle and air conditioning for a total package price of $984 and $1013.[27] Ford sold between 10,000 and 12,000 airbag-equipped Tempos and Topazes during their inaugural year, but the company interpreted this as a positive because the option was introduced mid-season with absolutely no advertising support.[28] It was also reported that the company was losing money even at an $815 price tag.

During the airbag race that ensued in the late 1980s and early 1990s, GM lagged behind Chrysler and Ford, but it did begin to offer optional driver-side airbags on its 1988 model year Oldsmobile Eighty-Eights and 1989 Ninety-Eights and Cadillac DeVilles. GM priced the option alone at $850, but also included it in an option package like Ford did with the Tempo where the net price of the airbag was $300.[29] Unlike the Ford assemblage of options, GM gave a $500 rebate directly to the consumer for purchasing one of the option packages including an airbag. One of the option packages included 15-inch aluminum wheels and automatic air conditioning, while the other included a high-end stereo and tape deck. An internal debate surfaced inside GM during this time as to whether lower-priced cars should offer optional airbags. The unofficial company position was that these models (e.g. Pontiac Grand Am and Buick Skylark) were too price-sensitive to carry the burden of added airbag costs.[28] Higher-priced cars, all-new models, and those getting major design and engineering revamping were thus designated as the top priority vehicles to receive airbags. The engineering and manufacturing people at GM leaned toward making airbags standard equipment because of the up-front engineering and manufacturing work necessary to make modifications in order to install the airbag system in the vehicle.

The Chrysler Corporation saw a completely different prospect for the airbag. First of all, Chrysler intended to forgo option packages and introduce airbags as standard equipment on its cars. Albert J. Slechter, the company's director of federal government affairs, explained: "The concept of an optional system tends to lose significance when you must have passive restraints in all vehicles. The idea of an optional system, certainly in passenger cars at this time, loses meaning. They'll be standard equipment as we move toward 100 percent."[28] Chrysler chose to install airbags in large cars and sporty cars first because it is less difficult to implement a driver airbag on a larger vehicle than a smaller one, and sporty cars were considered "appropriate" vehicles for the safety device. Chrysler fully expected that with the volumes being predicted for airbags, prices would come down and be "totally competitive in the marketplace." Slechter predicted: "As airbag volume rises over the years, there's a tendency for costs to be lower, because you're going to be amortizing development costs through that time frame."

Nissan Motor Co. offered optional driver airbags on its 1991 model year 300ZX and 1992 Maxima for $500, and on its 1993 and 1994 Sentra and NX for $575. Subaru made airbags optional on its 1992 Legacy for $800. GM offered optional airbags on the company's 1992 Saturn division cars for $625.

The emerging market for airbags in England is interesting to consider because there was no regulatory driver pushing the adoption of airbags along. The market in England, unlike Canada, is not dominated by American automakers, which allows for a better comparison. BMW announced it would offer airbags as optional equipment on all of its cars sold in Great Britain in 1992. The cost to the consumer of this option was reported to be 745£ (~$1340).[30] Mercedes-Benz, as the acknowledged leader of the airbag race, had already been offering optional driver airbags. In October of 1991 it was reported that Mercedes had slashed the cost of the airbag option nearly in half from 1433£ (~$2579) to 750£ (~$1350) perhaps to compete with other luxury automakers now offering optional airbags, or possibly because the cost had come down sufficiently to justify such a drastic cutting of cost.[31] Mercedes also began offering standard airbags on the company's more expensive models to stay a step ahead of the competition. One of these competitors was Volvo, which was no stranger to innovations in auto safety. Volvo began offering optional airbags on its mid-sized 400 series cars during the 1992 model year for 730£ (~$1314).[32]

3.2.3 Airbag Component Costs

A number of components comprise an airbag system. The prices of these separate components thus comprise the total price of the airbag system. The quality and type of the components varies greatly across manufacturers and vehicle segments leading to a great deal of variability. For instance, many luxury models will include airbags made out of soft leather, and possess greater complexity in the electronic control systems.

The cost reduction of airbag systems has been dramatic. This large system reduction is attributable to uneven subsystem reductions. A prominent airbag supplier contacted for the purposes of this study estimates that the cost of a standard airbag module, comprised of the inflator, airbag itself, and cover, has fallen from over $200 to less than $50 over the last fifteen years.[33] According to the supplier representative, the cost reduction is attributable to the large increase in production volume as well as through improved technology, particularly of inflators. Table 3-4 highlights some of the costs of components that comprise an airbag system. This table differs from the information presented in Table 3-3, which included seatbelt costs for some of the models, and additional airbag (e.g. side airbag) cost for other models. It is important to note that the costs have consistently fallen, while the complexity, reliability, and safety of the airbag systems have all risen significantly. In other words, the cost of a circa 1988 airbag system in 2000 would be substantially lower than a circa 2000 system costs. As will be discussed in Section 3.6.2, there has been a proliferation in technological innovation related to airbags in the last 15 years. Such innovation has helped keep costs stable, while at the same time greatly improving the performance of the airbag systems.

Table 3-4 Airbag Component Cost Summary

Vehicle/Year	*Control Module*	*Sensor(s)*	*Wire Harnesses*	*Driver Airbag + Inflator Assembly*	*Passenger Airbag + Inflator Assembly*	*Clock Spring Assembly*	*Total*
Ford Motor Co. 1987*	$42.60	$48.43	$37.88	$172.59	N.A.	N.A.	$391.35
Mercedes-Benz 1987*	$67.88	$106.46	$64.42	$191.22	N.A.	N.A.	$493.24
Ford Crown Victoria 1992**	$35.99	$13.64	$26.99	$73.79	$129.30	$17.83	$380.36
Acura Legend 1992**	$172.25	$36.07	$37.85	$64.18	$117.08	$19.00	$560.81
Mercedes-Benz 1997**	$155.65	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Chrysler Cirrus-Stratus 1998**	$108.04	Incl. in ACM Cost	$9.77	$65.18	$109.78	$3.29	$317.78
BMW 5-Series 1998**	$159.47	Incl. in ACM Cost	$18.12	$58.35	$94.26	$4.06	$334.26
BMW Z3 1998**	$156.33	Incl. in ACM Cost	$17.45	$67.90	$110.50	$3.94	$361.50
Ford Taurus 2000**	$96.16	Incl. in ACM Cost	$0.00	$81.34	$103.45	$3.29	$313.93

Table Notes: All values are Retail Price Equivalents in $2000. Airbag systems do not include seatbelt cost, but do include knee bolster and other related restraint system cost. **Sources:** Khadilka, Fladmark et al., Spinney et al.

3.3 EVOLUTION OF COMPLIANCE COST

3.3.1 Cost Reductions of Airbag Systems

Arguments concerning airbag cost contributed greatly to the delay in implementing a passive restraint standard, but once a regulation was adopted; cost was not much of an issue. This was partly due to the large drop in airbag system costs. Much of this reduction was achieved through economies of scale and learning effects. Out of the roughly 10 million 1988 model year passenger cars sold in the U.S., about 220,000 contained a driver-side airbag, and greater than half of these were from luxury European makers. As marginal as the market was at the time, the U.S. did comprise the largest automotive airbag market in the world by a wide margin. Ten years later, every new passenger car sold in the U.S. and virtually all light trucks were equipped with dual frontal airbags. Clearly, the cost structure, as well as all other aspects of the industry, underwent profound changes during this period. At the same time, the quality, reliability and technology in general of the airbag systems was enhanced greatly as well. Comparing the cost of a 1988 and 2000 airbag system is hence an apples and oranges comparison, but the alternative of comparing what a 1988 system would cost in the year 2000 is also problematic because cost data is not available for that level of analysis. All of the costs discussed below are cost to consumers or retail price equivalents (RPE), which include all relevant markups, unless noted otherwise.

A teardown analysis that looked at the costs of airbags for the Mercedes-Benz and Ford Tempo systems respectively was conducted in 1988. This study determined that the cost for a Ford driver-side airbag was $391 at a production rate of 350,000 units and $1,233 at 25,000 units (2002$; See Figure 3-3).[20] The cost to Ford Motor Co. was considerably higher than $1,233 since the company sold only 13,471 airbag-equipped 1988 model year cars. Before lowering the price considerably due to lack of demand, Ford offered the airbags on MY1987 and 1988 Tempos and Topazes as an option for $815 ($1,233 in 2002$), and admitted to selling them at a loss.[28] By way of comparison, another teardown employing the same methodology (see Appendix F) found that a driver-side airbag on a 2000 Ford Taurus had a cost of about $180 at a production volume of 250,000 units.[22] This $180 figure also included the added cost due to some shared components with the passenger-side system. Unlike the 1988 cost estimates, the actual cost in this case was most likely lower than $180 per unit since Ford sold 382,035 MY2000 Ford Tauruses, and similar airbag systems were found on all of the company's nearly 1.7 million MY2000 passenger cars sold in the U.S., not to mention the company's nearly 2.5 million MY2000 light trucks sold in the U.S., all of which had a dual airbag system. Another teardown study conducted in 1992 examined the Ford Crown Victoria. The analysts determined the cost for the driver-side airbag system to be about $251 in 2002$ at a production rate of 300,000 units.[21] This estimate suggests that much of the eventual cost reduction had occurred in the first few years after airbags were introduced, and the rate tailed off considerably after large quantities of airbag systems were being produced. Ford Motor Co. sold roughly 707,000 MY1992 cars equipped with driver-side airbags and another 284,000 cars outfitted with dual airbags. The 1992 airbag systems resembled the 1987 systems more closely than those of 1998 and beyond. A trend analysis conducted by NHTSA compared 1990 and 1998 airbag systems, and found great changes in airbag design, airbag placement, inflator type and pressure characteristics, and number, type, and placement of airbag controller sensors between the early and later systems.[34]

For the 1987 Mercedes-Benz system, the cost was estimated at $492 at a production volume of 350,000 and $670 when 150,000 units were produced (2002$; See Figure 3-3). In this case, the cost was also higher than $670 because only about ½ of the 150,000 airbags were sold annually in the U.S. around this time (77,945 for MY1988 and 78,840 for MY1989). Mercedes offered optional driver-side airbags for about $900 ($1,400 in 2002$) on its 1984-85 models.[35] By 1989, it was reported that Mercedes was making money on its airbag system, and that the safety device had been standard equipment on all of the company's models sold in the U.S. since MY1987.[26] Cost estimates for later Mercedes' airbag systems were unavailable, but the cost of a driver-side airbag on another luxury sedan – the 1992 Acura Legend – was estimated to be $444 in 2002$.[21] Acura sold nearly 66,000 dual airbag-equipped MY1992 cars in the U.S., and in 1989, 1990, and 1991 had sold 72,072, 57,133, and 61,321 cars respectively with driver-side airbags. So although Acura lacked the level of airbag experience Mercedes possessed, the subsidiary of Honda had been producing the safety systems at comparable volumes. A teardown study conducted in 2000 found that cost of two MY1998 BMWs driver-side airbag systems was $240 for the 5-series and $251 for the smaller Z3 at a production volume of 250,000 units. The system complexity of the BMW system is comparable to that of Mercedes, so comparing these figures with those generated in the 1987 study for Mercedes is reasonable.[36] Again the cost of airbag systems is shown to have fallen considerably, particularly over the first few years that airbags were introduced.

Improvements in certain areas of the airbag systems led to the most dramatic cost reductions. A representative for the airbag supplier, Takata, estimates that the producer cost of a standard airbag module, comprised of the inflator, airbag itself, and cover, has fallen from over $200 to less than $50 over the last fifteen years.[33] According to the supplier representative, the cost reduction is attributable to the large increase in production volume as well as through improved technology, particularly of inflators. Sensors have also contributed significantly to the price decline. A related air bag industry trend is the move toward silicon micro-machined accelerometers in a single-point configuration. These tiny sensors are cheaper than other types, and were estimated in 1992 to have a producer cost of about $5 to $6 each in large production volumes.[38] Similarly, Siemens Components Inc. developed an improved electronic sensor for airbag systems in 1994 that led to a manufacturing cost of $2.50 to $3.00 in volume.[39] Airbag systems in early years relied primarily on 3 or 4 electromechanical sensors (85% of systems in MY1990), while later systems typically use only one electronic sensor (50% of systems in MY1998).[34] In summary, large cost reductions were achievable due to a confluence of factors, particularly, technological innovation and learning effects, economies of scale, and pricing pressure from OEMs and an intensely competitive environment.

The effect of economies of scale on airbag components has been well documented. Table 3-5 highlights the expected cost reductions based upon escalating production runs generated by airbag supplier groups for a 1979 Congressional hearing. Even at this early date, the airbag suppliers exhibited a prophetic knowledge of the

Table 3-5 Expected Cost Reductions as a Function of Production Volume

Volume	Driver Bag + Inflator Module	Passenger Bag + Inflator Module	Sensors + Diagnostic Parts
13,000	Base	Base	Base
25,000	34 %	8 %	7 %
100,000	62 %	40 %	19 %
200,000	68 %	50 %	22 %
900,000	75 %	67 %	24 %

Source: Reference [40]

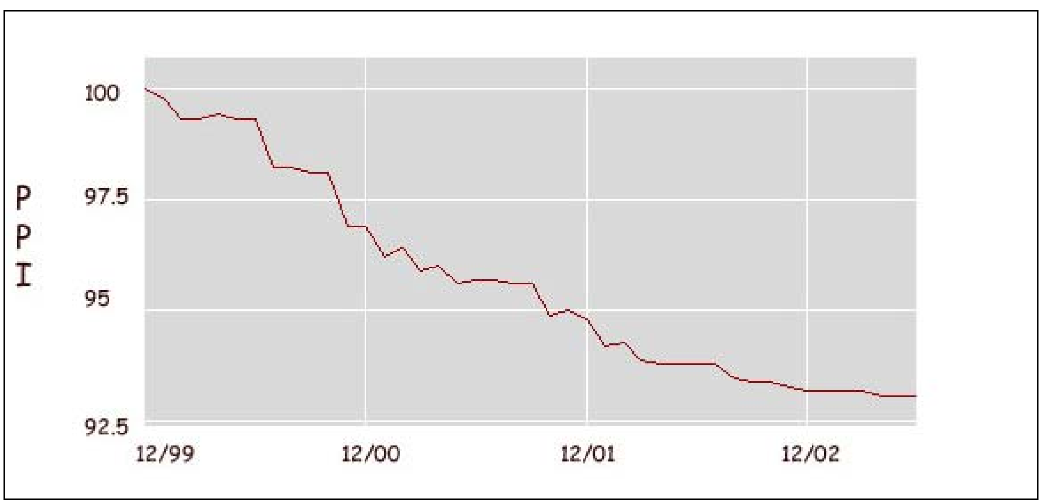
relationship between cost and volume. The retrospective analysis offered in the above paragraphs generally agrees with the prospective one given by the airbag suppliers.

These are exclusively production-level price effects, but when airbag production ramped up, the technology did not stand still. Airbags became more reliable and safer, while at the same time price came down. Although the reduction in price of airbag systems did not necessarily behave uniformly across time or production schedules, it can be argued that the quality-to-price ratio for airbags has steadily climbed from learning and production volume effects. The estimated economies of scale effects shown in Table 3-5 have been substantiated by the actual airbag component cost trends over time as shown in Table 3-4 and Figure 3-2.

3.3.2 Experience Curves for Airbag Systems

Figure 3-1 shows the trend in Producer Price Index (PPI) since the BLS started tracking airbag assemblies and parts data in December 1999. The PPI tracks the average change in net transaction prices that domestic producers receive for the products that they make and sell thus PPIs are output price indexes, not input cost indexes. The price quotations that the PPI uses to build these indexes come from a statistically chosen sample of representative transactions obtained from a representative sample of producers in each of the 600 or so industries for which PPI tracks data.[41]

Figure 3-1 Trend in Producer Price Index for Airbag Components



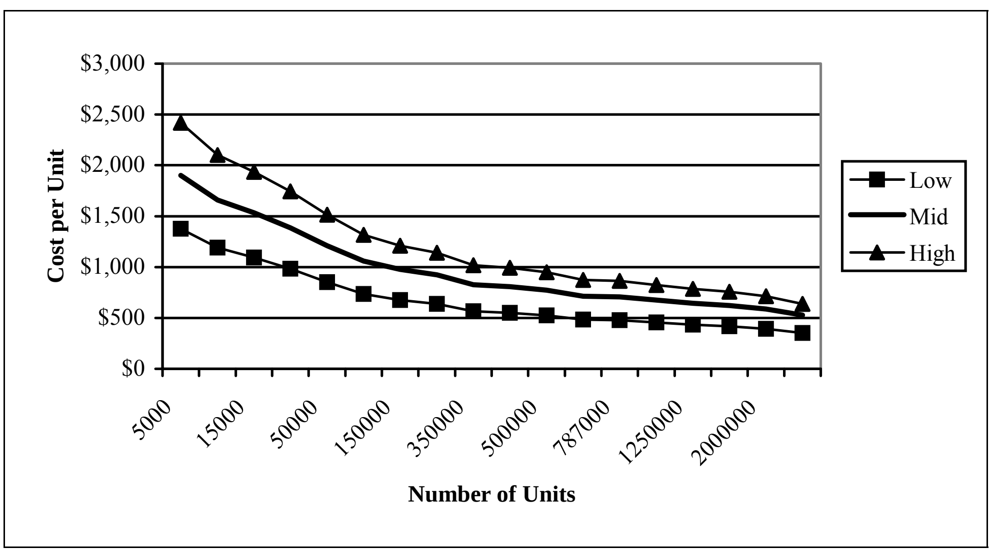
Source: Bureau of Labor Statistics, See: http://www.bls.gov/ppi/home.htm

The drop in PPI indicates that prices received by producers for finished airbag systems and modules fell about 8% in the three years or so it has been tracked. The curve also appears to have leveled off somewhat in the last 6 to 8 months. The fall in prices most likely has little to do with production rates since the airbag industry has been firmly established during this timeframe. Part of the price drop may be a response to tightening imposed by the automakers as the economy declined and profit margins shrank, but another explanation may involve a combination of the following:[42]

- Operator learning
- Improved methods, processes, tooling, machines and design improvements for increased productivity
- Management learning
- Debugging of engineering data
- Production rates
- Design of the assembly or part, or modifications
- Specification or design of the process

The reduction in cost of airbag systems over time is thus a confluence of these factors: the learning effects that accumulated as airbag suppliers and related companies formed an established, profitable industry, the rapid expansion of the industry that led to the well-documented economies of scales effects, and the innovation effects that helped to inform the design and management processes. These effects that both lowered cost and improved quality and performance are at least partially additive and are difficult to disentangle from one another. Figure 3-1 shows what is essentially a *de facto* experience curve, which captures this confluence of factors. Unfortunately, BLS only recently started tracking this PPI sub-index, so the curves for airbag components during the crucial period of 1988-2000 must be ascertained using another method.

Figure 3-2 Estimated Experience Curves for Dual Airbag System Cost



The learning curves in Figure 3-2 were estimated by performing a regression analysis using a power function, which has traditionally been the functional equation form when estimating learning effects. Due to the limited data points from which the equation was derived, the results should be used for illustration only. Table 3-6 shows the descriptive statistics from the analysis. The following equation is referred to as "Wright's Cumulative Average Model."[43]

$$\mathbf{Y = AX^b}$$

Y = cost per unit in constant 2002$
X = number of units
A = Cost for the first unit produced
b = slope of the function when plotted on log-log paper

Table 3-6 Results from Experience Curve Estimation for Airbag Consumer Cost

	Low Price	Mid Price	High Price
A	8,156 (3.87)	10,051 (3.84)	13,688 (3.25)
b	-0.2089 (-9.79)	-0.1956 (-9.11)	-0.2035 (-8.01)
R^2	0.85	0.83	0.79
Cumulative Production Cost 3,500,000 Units	$1,549,731,339	$2,295,008,094	$2,802,224,371
Average Production Cost 3,500,000 Units	$443	$656	$801

Notes: t-statistics in parentheses

Detailed cost information for airbag components and modules is difficult to gather. From a limited set of data points, a reasonably accurate set of experience curves can be developed for illustrative purposes. In this simple model, industry estimates would tend to follow the high price curve, while government estimates, as expected, would fall in the bottom range. Although the curves may seem close together the cumulative cost difference between high and low estimates is almost $1.3 billion.

3.3.3 Other Mechanisms that have Facilitated Cost Reductions

Airbag suppliers have been under tremendous pressure from automakers to keep finding ways to lower per unit costs. The extremely relatively low profit margins of the motor vehicle industry, along with the control that auto manufacturers exert upon suppliers, create a highly competitive market. This can be seen in figures in the following section where the CPI and PPI for the motor vehicle industry increase more slowly than average. The 2000 SEC 10k annual report for Autoliv, an airbag supplier that controls 29 percent of the global market, more than any other single supplier, sums up this phenomenon.

> As a consequence of the major automobile manufacturers' strong purchasing power, and the competitive pressures on car occupant restraint system suppliers to increase such suppliers' manufacturing capabilities, the unit prices of airbag systems and seat belts will continue to decline in the future. In addition, similar to other automobile component manufacturers, Autoliv expects that Autoliv and its subsidiaries will, under certain circumstances, quote fixed or maximum prices for long-term supply arrangements. The future profitability of Autoliv will depend upon, among other things, its ability to continue to reduce its per unit costs and maintain a cost structure, internally and with its suppliers, that will enable it to remain cost-competitive. Autoliv's profitability may also be influenced by its success in designing and marketing technological improvements in car occupant restraint systems.[44]

The above statement clearly outlines a major airbag supplier's general strategy with respect to cost. Airbag suppliers, like most companies, must balance between effective cost-cutting strategies and continuing to produce a reliable quality product.

3.4 Compliance Cost Impact on Vehicle Pricing

Many auto industry observers have contended that competition is the primary determinant of automobile pricing.[45] If this were true, it would not always make sense for automakers to pass on the costs of added equipment identically across their fleet of vehicles. Value pricing, popularized by GM with its launch of Saturn, is another strategy increasingly used by automakers. Also known as one-price selling, value pricing consists of a car with a fixed set of popular options and one usually nonnegotiable sticker price.[46] It was also reported in the same source that European manufacturers such as Mercedes-Benz and Saab have been cutting the cost of production, and effectively passing the savings on to the consumer by keeping price inflation to a minimum. The results of an economic analysis also suggest pricing behavior in the automobile market is consistent with theory governing price leaders and followers, as opposed to a mutually independent pricing rule.[47] This finding also contradicts to some degree the idea of perfect cost pass-through to the consumer. Given the extreme complexity of car pricing, and the often uncertain role that costs due to compliance play, documenting examples of how price changes have accompanied adjustments to vehicles will be helpful at reaching a fundamental understanding of the process.

Meanwhile, some auto industry analysts hold that carmakers are not able to fully recover the cost of regulated technologies, since these features are added uniformly across all vehicles disallowing for differentiation from competition.[48] The argument follows that OEMs can add the cost of new technologies to the sticker price, but because of over capacity and intense competition, it is difficult for automakers to recoup the cost directly and quickly. Innovations that differentiate the vehicle from the competition allow automakers to charge higher prices for some vehicles and in some segments of car buyers. In general, this only lasts for a few years by which time the new feature has already been integrated across many lines, or has been dropped due to small demand. The reality, though, is that pricing is part of a highly complex planning, manufacturing, and marketing process.

3.4.1 Compliance Strategies

Automakers utilize a number of pricing strategies to help mitigate the impact of compliance induced cost increases. The costs associated with emissions and safety regulations vary from small to significant. First and foremost, automakers seek to expand, or at least maintain, their market share. This can be jeopardized by the "sticker shock" that consumers will experience if prices are raised substantially in an across-the-board manner. For this reason, automakers recover compliance costs in a differentiated and disproportionate manner across their entire line of vehicles. Some of the strategies used by the auto manufacturers to maximize sales volume, while at the same time recouping compliance costs, will be presented in this section of the report and include the following.

- Automakers passed the costs incurred by regulation through vehicles that are in higher demand and/or have a higher profit margin. As will be shown in sections 3.4 and 4.1, and in Appendix A, the added cost of airbags is disproportionately passed on in more expensive vehicles, and to a lesser extent, better selling ones.
- If the technology is a future one, and is being introduced in a limited manner then only a portion of the full cost (including R&D) is reflected in the price of the

vehicle (e.g. vehicles would have been prohibitively expensive if the retail price truly reflected the high cost of airbags when the devices were first introduced, as with hybrid electric vehicles and a host of other new automotive technologies).

- Automakers may recoup the cost over the course of a number of years and number of models to avoid price shock. Clearly automakers must recoup cost much more often than not to remain profitable and viable. In the case of airbags, the regulation took this into consideration by allowing a gradual introduction of airbags across an auto manufacturer's vehicle lines.
- Offsetting reductions in standard equipment (decontenting) on some models may be used to mitigate the effects of cost pass-through pricing. There is some evidence of this with respect to airbags. For instance, GM recently decontented (i.e., eliminated) ABS and side airbags from some models as a cost-cutting measure.
- The impact of cost pass-through pricing may be tested by a series of minor price increases. This strategy is difficult to verify, but has been used by automakers to 'test the waters' and avoid 'price shock.'

Automakers also tighten their belts in other areas of their operation to maintain profit levels. These include the increased scrutinizing of non-regulatory project proposals and the exploitation of redundancies, scale economies, and other cost-cutting strategies in achieving compliance. Tooling, manufacturing, and materials management costs are also minimized through standardization techniques across differentiated product lines.[49]

3.4.2 Vehicle Pricing Policies of the Automobile Industry

Pricing policy is one of the most guarded decision-making practices of automakers. While an outsider could not document or accurately specify actual pricing decisions, a general understanding and characterization of pricing actions can be inferred from the literature and from the automakers' actions in the marketplace. Pricing is an integral component of automakers' managerial operations. For simplicity, price can be considered the point "where the value of the product to the customer and the company's compensation for producing the product intersect."[50] Pricing methods are based on an auto manufacturer's overall business strategy. The obvious primary objective of private firms is profit maximization. But in the auto industry with its highly differentiated product lines this does not necessarily translate to profit maximization strategy for each vehicle line in its portfolio. In addition, firms may adopt a sales volume objective, which has traditionally been GM's approach for expanding, or at least, maintaining market share. As the industry price leader, GM has traditionally been able to establish its own cost-based pricing that is denoted either by markup pricing or rate of return pricing.[51] GM has lost its ability to dominate automobile price setting as its market share has shrunk and foreign competitors such as Toyota and Honda have found ample territory aside from price in which to compete with GM. Competition-based pricing is another method automakers use when setting prices. In order to stay competitive in a market segment, the price set by an automaker must coincide both with consumers' willingness to pay and be within the range of prices of comparable vehicle offerings. Better quality, reliability, comfort and safety attributes, and other characteristics that differentiate a vehicle from another vehicle in its segment allows for a higher price. The economics literature is filled with studies that examine the price-quality relationship.[52] The brand in addition to the price may assist the consumer in determining the overall quality of the vehicle. Pricing that is too low may have the undesired consequence of convincing consumers the product is of inferior quality. Of course, pricing that is too high may also turn off consumers who believe that the price is not a fair one. In recent years, the Internet in particular, has given consumers an advantage in new vehicle transactions by making the dealer cost readily available. This cost transparency, in addition to the proliferation of rebate offers and other financial incentives, has made the MSRP an increasingly inexact measure of the actual transaction price.

A detailed 1978 report prepared for the US Department of Transportation found there to be four overarching factors that influence automakers' pricing policies.[49]

1. ***Volume Orientation*** – According to the report, theoretical studies of elasticity indicate that demand for new automobiles is not exceptionally sensitive to price increases. But automakers position their product lines against those of their competitors in such a way as to maximize their market share. The importance in pricing then becomes how a certain vehicle is priced with respect to comparable, competing vehicles. Automakers are usually willing to shrink profit margins to some degree in order to sell more vehicles – especially when they have excess manufacturing capacity and also because the initial selling of a vehicle is just the first transaction in a revenue stream that may last the lifetime of the vehicle.
2. ***The Product Planning Process*** – There is no evidence that automakers employ a uniform cost-based approach across their fleet of vehicles when setting prices. Instead, profit margins in terms of both return on sales and return on investment vary a great deal from vehicle to vehicle, and these inconsistencies are recognized by automakers as essential in the effort to maintain a wide range of product lines that appeal to a spectrum of market segments. For example, automakers can make as much as $15,000-$20,000 on high-end luxury cars and SUVs, but at the same time, essentially break even on fuel-efficient, 'budget boxes.' As a result, price targets are principally determined from both past experience and expectations of future purchase behavior. A price target (sometimes but not always the MSRP) is the amount an automaker hopes a consumer will pay for a vehicle. The fundamental question the automakers ask is: Given current market conditions, how much are consumers willing to pay for a vehicle that has these attributes and features?
3. ***Parochialism*** – This describes the tension that exists within an automaker between finance groups that favor pricing policies that lead to higher profit margins, and sales groups that favor slightly deflated pricing in order to achieve greater sales volume.
4. ***Fine Adjustment Mechanisms*** – While automakers set an MSRP when a vehicle is introduced, this list price may change numerous times over the course of the year if consumer response does not meet original expectations. The manufacturer may adjust the price and/or demand by offering rebates directly to the public, increasing advertising, enacting a sales incentive program, presenting a special promotion such as option packages at a discount, providing the dealer with a rebate, or offering fleet discount programs to volume buyers. Dealers who are left

with excess inventory may be forced to take similar measures that eat into their profit margins.

3.4.3 Cost Transfer for the Introduction of Airbag Systems

The pivotal 1990 model year, driven by the passive restraint regulation, witnessed the first widespread introduction of driver airbag systems in the U.S. vehicle market. The number of such cars expanded from well under one million to well over two million vehicles. It was reported that Ford Motor Co. and Chrysler Corp., the two companies spearheading the airbag race, would pass on to consumers the cost of the federally mandated airbags, contributing to price hikes as high as $1,300 on some models.[53] For instance, it was reported that Chrysler would boost prices on its 1990 model cars by an average of five percent. The company blamed much of the rise on the cost of federally mandated passenger restraints, particularly airbags.[26] Chrysler added more than ½-million airbag-equipped cars over the previous year, which cost the company upwards of a quarter of a billion dollars if each unit installed is assumed to cost $500. Similarly, Ford and Chrysler had tentatively increased prices 3 percent to 9 percent over 1989 on early 1990 car and truck models being sold to fleet owners, in part because of the new government requirement for air bags or passive seat belts.[54] Spokespersons for Ford, Chrysler and General Motors also confirmed that the automakers would pass along to buyers the cost of the mandated safety equipment on 1990 model year cars. The Big Three stated that by choosing to install the pricier passive restraint option for many models, the companies had to raise prices for 1990 cars much more than their Japanese competitors, which equipped nearly all their models with the considerably less costly automatic seatbelt (See Appendix B for detailed installation rates).[55] The Big Three raised their prices by an average of $805, compared with $205 for Japanese cars. While 1990 was a very pivotal year for Ford and Chrysler, GM committed to airbags later, so the impact was felt more acutely for GM in the 1991 and 1992 model years. GM announced big price increases on some of its 1992 models that the company said largely reflected the addition of airbags as standard equipment.[56]

Tables 3-7 and 3-8 show the effect that making airbags standard equipment has on vehicle prices on an aggregate basis. The Driver-side airbag column indicates that a driver airbag was made standard, while the passenger-side airbag and dual airbags columns indicate that a passenger airbag and dual airbags respectively were made standard. Also included are the impact of ABS and the average cost increase for years when neither airbags nor ABS were made standard. The tables also break down the average cost and percentage increase by a number of price brackets and vehicle classes to provide a clearer picture of the nature of the cost pass-through. The vehicles analyzed were the base versions of particular models during the timeframe of 1988 to 2000. *Ward's Automotive Yearbook* was used as the source for vehicle price data and available standard equipment. Other changes between model years were not taken into account in the analysis. Automobile manufacturers traditionally make annual changes to vehicles to enhance their marketability and to meet Federal and State requirements. These changes include interior and exterior trim, minor exterior body parts, major structural design and styling, drivetrain, and the platform. These changes may or may not be directly reflected in the price of the vehicle. Trim changes usually occur every year and include the interior trim, exterior bumpers, paint, and front and rear styling. Minor changes to exterior body parts occur every two to three years and include fenders, hood, and trunk lid, but do not include structural parts. A major change to structural design and styling may occur about every four years and includes distinctive changes to the exterior body parts, which may change the dimensions of the vehicle, but not the drivetrain. Changes to the drivetrain often occur every two to three years and include engine displacement, type of engine, transmission, and drive wheels. The change to the body family or platform occurs when an entirely new vehicle is designed.[57] The vehicle prices were converted into constant 2002 dollars using the new vehicle consumer price index furnished by the Bureau of Labor Statistics.

Table 3-7 Change in Average Vehicle Price when Airbags & ABS are made Standard (Price)

Car Price (2002$)	$/% change	No Change (n = 556)	Driver-Side Airbag (n = 78)	Passenger-Side Airbag (n =72)	Dual Airbags (n = 15)	ABS standard (n = 137)
< 15k	$ %	$386 3.00%	$393 3.18%	-$311 0.11%	$657 5.96%	$770 6.74%
15k – 25k	$ %	$581 3.12%	$1,055 5.92%	$799 4.29%	$119 0.66%	$1,148 5.99%
> 25k	$ %	$830 2.54%	$1,129 3.59%	$1,341 3.43%	$1,701 5.40%	$1,135 3.15%
Average All Vehicles	**$** **%**	**$606** **2.76%**	**$861** **4.14%**	**$898** **3.34%**	**$581** **3.51%**	**$1,045** **5.28%**

Table Notes: 1.) The (n) refers to the number of consecutive year vehicle model pairs. In the case of 'no change,' there are 120 distinct models spread over multiple years, so there are a total of 556 Δ price entries. In the case of the other variables, (n) equals the number of vehicle models tested. **2.)** The cost change is calculated as an aggregate average. **3.)** No Change simply means airbags or ABS were not made standard, although other major changes (styling, new attributes, etc…) may have been made. **4.)** The sample covers model years 1988-1998.

Table 3-8 Change in Average Vehicle Price when Airbags & ABS are made Standard (Veh. Class)

Vehicle Class	$/% change	No Change (n = 556)	Driver-Side Airbag (n = 78)	Passenger-Side Airbags (n =72)	ABS standard (n = 137)
Small Car	$ %	$268 1.97%	$370 2.67%	-$296 -0.33%	$1,502 10.29%
Midsize Car	$ %	$449 2.51%	$1,175 7.68%	$1,185 7.15%	$464 2.60%
Large Car	$ %	$572 2.77%	$1,487 7.62%	$1,035 4.88%	$1,445 6.94%
Luxury Car	$ %	$710 2.00%	$955 2.80%	$1,170 2.68%	$1,159 3.61%
Sports Car	$ %	$820 3.99%	$551 3.42%	$1,023 5.78%	$927 4.87%
Minivan	$ %	$1,448 6.52%	$1,866 10.66%	$1,658 6.88%	$912 5.22%
SUV	$ %	$1,463 5.04%	$1,208 4.35%	$1,827 5.82%	$1,351 6.40%
Average All Vehicles	**$** **%**	**$606** **2.69%**	**$861** **4.14%**	**$898** **3.34%**	**$1,045** **5.28%**

Table Notes: Same as Table 3-7; Consult Appendix C for complete descriptive statistics associated with this analysis.

The introduction of ABS as standard equipment was associated with the greatest degree of change in price homogeneity in dollar terms. Vehicles that do not undergo a safety attribute installment display the most consistent change in percentage change in price. The cost of ABS, which has been reported to be in the neighborhood of $500 to $1000 dollars or more depending on the make of vehicle, is passed on fairly consistently to consumers of all price-level cars. A more stable cost pass-through may accompany the addition of ABS because automakers had much more freedom to choose which vehicles would receive the safety upgrade. Such a straightforward pass-through is not the case for airbags perhaps partly due to the requirement to add the safety feature to all vehicles over a relatively short period of time.. When a driver airbag is added, the cost burden is disproportionately placed upon the most common price-level of cars (i.e. $15,000-$25,000). Strangely, cars costing over $25,000 have a smaller dollar figure increase than when no safety feature is added. The small sample sizes (n) mean that the results are not statistically significant, and may be skewed in one direction or the other.

Figure 3-3 Average MSRP Increase with Airbags, ABS, and Neither Added

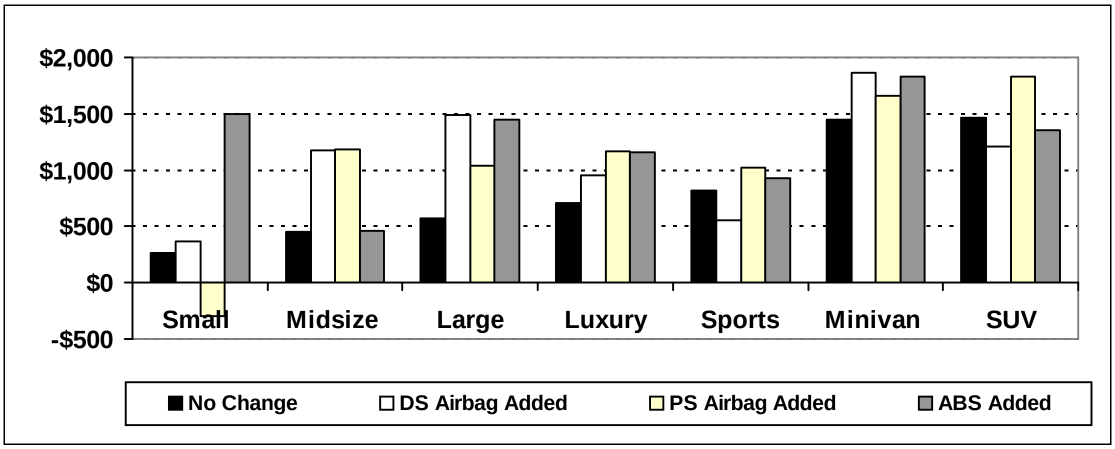
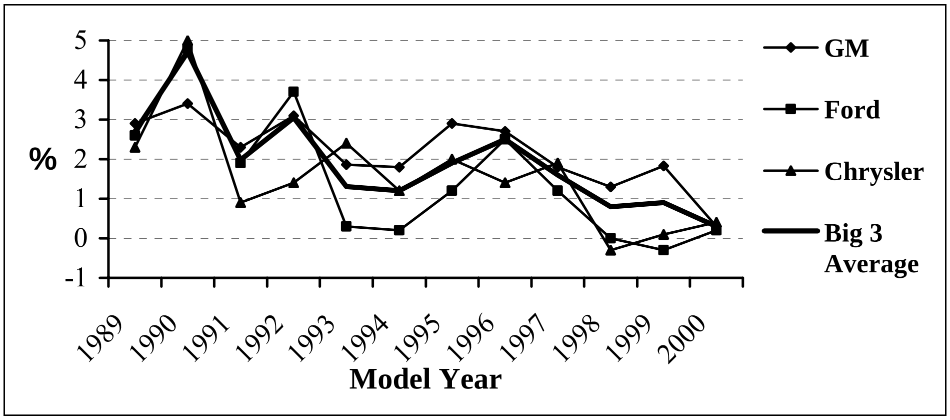


Table Notes: The data used in this figure is for vehicles (all major manufacturers) from 1988 to 1998. These results are the same as those presented in Table 3-8. DS = Driver-Side; PS = Passenger-Side

As Figure 3-3 shows, the trend in price shifts indicate that larger vehicles receive a higher price increase on average than small cars. When a car moves from having a single airbag to dual airbags, the cost pass-through is weighted toward the more expensive cars (as indicated by the fact that the price increase is no greater for 2 airbags than one, even though the cost much be greater). In this case the price of cars that cost under $15,000 actually see lowered prices in constant dollars. Automakers decided to forgo an incremental installation on some models, and move straight to dual airbags. This action is in many cases regulatory-driven because automakers thereby satisfy the dual airbag requirement that went into effect during the 1995 – 1998 model years. In this instance, the most prevalent price-level of cars once again yields unexpected results. The cost of the dual airbag systems is clearly not passed on initially to the consumer of cars costing between $15,000 and $25,000. The data indicate that the unregulated technology, ABS, has a higher price premium than airbags. This may be due to automakers' opinion that there is less demand for a regulated safety feature, so the added cost must be kept low in order to not negatively impact sales. More than anything these tables along with Figure 3-4 show the unpredictability and complexity of automaker's pricing policies. Consult Appendix A for detailed price and sales analyses in response to the introduction of airbags for individual vehicle models. The results in the appendix more clearly show how automakers pass on added costs across a number of their highly differentiated vehicle offerings. For the most part, higher-end cars receive disproportionately higher price increases than their more budget-targeted counterparts. There is also a great deal of fluctuation in price setting from one year to the next, which highlights the range of factors, only some of which are cost-related, which help to determine the price of a new vehicle.

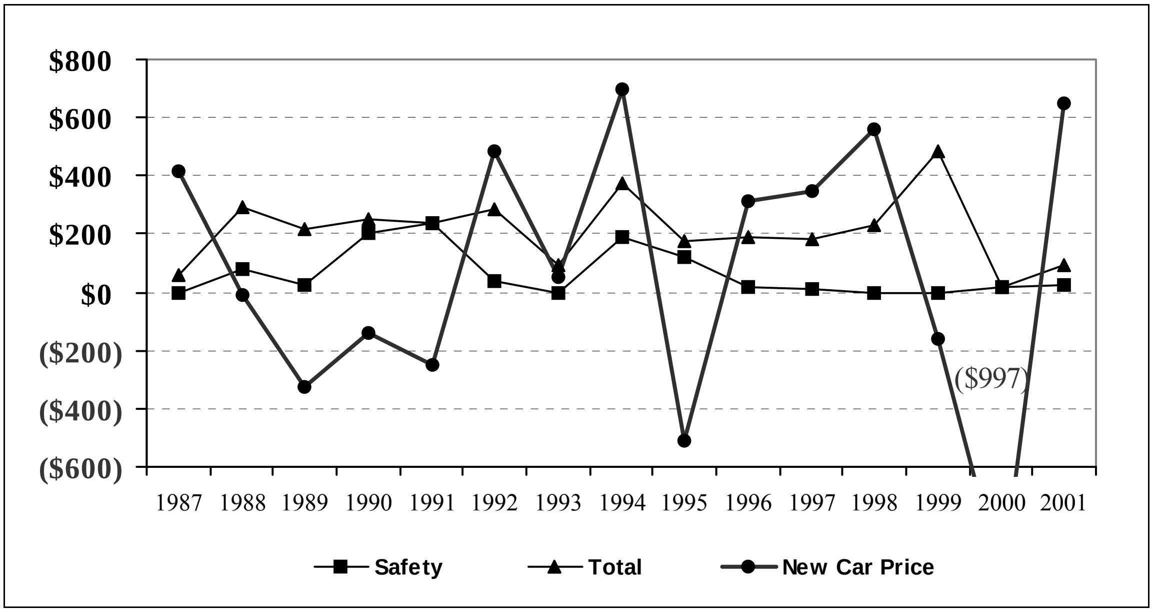
Figure 3-4 Average Fleet-Wide Percentage Annual Increase in New Car Prices



Source: Numerous issues of *Automotive News* (1988-2000). The percentage change is strictly price increases (i.e. Cost of quality improvements like those generated by BLS to a car are not factored into the change).

The Bureau of Labor Statistics publishes the price differential for quality changes to new vehicles. These quality changes include such items as powertrain improvements, corrosion protection, theft protection, changes in levels of standard and optional equipment, as well as mandated safety and emissions control improvements. For example, BLS tracks the price change resulting from the Federal Motor Vehicle Safety Standards, such as FMVSS 208, that governs airbags, and the price change in accordance with the Clean Air Amendments of 1990. BLS decided that, beginning in 1999, it would no longer treat modifications to goods and services that are made solely to meet air quality standards as quality improvements in the CPI. Price increases associated with such modifications were to be treated as increases in the index. The rationale behind this decision is that a change in pollution control in no way changes the satisfaction derived from the vehicle by the individual consumer. This fundamental difference between emissions regulations that primarily lead to *public benefits* and safety regulations where the derived *private benefits* are transparent will be discussed at length in Section 4.4. Consult Appendix D for a synopsis of quality adjustments for passenger cars from 1969 to present.

Figure 3-5 **Average Retail Price Changes for Quality Improvements[1] and Average Change in Car Price[2] ($2001)**



Source: Bureau of Labor Statistics, Reports on Quality Changes for New Cars as reported in *Ward's Automotive Yearbook 2002.* U.S. Department of Commerce, Bureau of Economic Analysis, *National Income and Product Accounts*, underlying detail estimates for Motor Vehicle Output, Washington, DC, 2002. (Additional resources: www.stat-usa.gov) These data apply to passenger cars only (not light trucks). See **Appendix D** for Source Data.

BLS estimates the value of quality change based on a review of data supplied by producers for similarly equipped previous model year and current model year domestic models priced for the Producer Price Index. Essentially, price changes above and beyond the change due to quality improvements can be construed as a change that is not covering an explicit cost. An implicit cost such as this would perhaps cover manufacturing or some other cost that would not be considered to add quality to the new vehicle. BLS lists both producer prices as well as the retail price equivalent of quality improvements. Figure 3-5 highlights the retail price adjustments over the period between 1987 and 2001. The most important years for passive restraint regulation and airbags are 1988 ($78.12), 1990 ($205.26), 1991 ($239.60), 1994 ($188.94), and 1995 ($120.36). The cost figures in parentheses are the retail safety adjustments, which are almost entirely attributable to passive restraints for those years. For the 1988 model year, the regulation called for 25% of automakers' passenger cars to be equipped with passive restraints up from 10% the previous year. In 1990 this number jumped from 40% to 100%, which was reflected in the price increase. Up to this point, a mix of mostly automatic safety belts and some driver airbags caused the cost of these mandated safety improvements. This changed in the following years when airbag installation approached 100% of vehicles. Table 3-9 highlights the compliance cost per vehicle for passive restraints according to BLS data. Note that cost appears to be spread out over the course of a number of years and, if these numbers are to be believed, may not be recouped at all judging by the average change in new car price. Of course, the average change in new car price is not a good measure for determining cost pass-through dynamics because it fails to get at what is happening on a manufacturer by manufacturer (and vehicle class by vehicle class) basis.

Table 3-9 Summary of Statistics related to the Introduction of Airbags (1987-1997)

Model Year	Average per unit safety cost[1] ($2001)	Average Change in New Car Price[2] ($2001)	Number Cars Sold w/ Auto Seatbelts[3]	Number Cars Sold w/ Driver Airbags[3]	Number Cars Sold w/ Passenger Airbags[3]	Passenger Car Sales[3]
1987	$0.00	$355.59	1,570,000	106,789	0	10,277,000
1988	$78.12	-$304.24	3,100,000	210,137	0	10,530,000
1989	$27.11	-$537.19	3,900,000	630,295	0	9,772,000
1990	**$205.26**	**-$388.66**	6,050,000	2,331,614	20,657	9,300,000
1991	**$239.60**	**-$492.60**	5,100,000	3,015,945	72,456	8,175,000
1992	$37.68	$202.55	3,800,000	3,995,231	431,988	8,214,000
1993	$0.00	-$39.59	2,500,000	5,030,813	1,257,478	8,518,000
1994	**$188.94**	**$323.74**	950,000	7,238,642	5,008,146	8,990,000
1995	**$120.36**	**-$684.01**	0	8,152,637	7,220,844	8,735,197
1996	$16.31	$125.56	0	8,366,340	7,911,639	8,653,927
1997	$8.97	$164.22	0	8,200,000	8,200,000	8,257,404

Sources: 1) Bureau of Labor Statistics, Reports on Quality Changes for New Cars as reported in *Ward's Automotive Yearbook 2002***. 2)** U.S. Department of Commerce, Bureau of Economic Analysis, *National Income and Product Accounts*, underlying detail estimates for Motor Vehicle Output, Washington, DC, 2002. **3)** Ward's Automotive Yearbook, (Various Years).

3.4.4 Impact of Airbag Regulation on the Auto Industry

Motor vehicle manufacturing accounted for 3.7% of the overall U.S. GDP in 2000.[58] The US automobile market is the largest in the world, and the automotive industry ranks among the top in the nation in terms of R&D spending and employee payroll.[59] Although average profit margins tend to be relatively small, great variability can be found across vehicles. American automakers in particular display a range of profit margins from close to zero for some vehicles to upward of $20,000 for others, such as luxury SUVs. Many small and midsize cars from Detroit such as the Dodge Neon, Chevrolet Malibu and Ford Focus have very little if any profit margin, but play an important role in helping automakers meet CAFE standards and attracting first-time buyers. American automakers have increasingly moved away from passenger cars in favor of light trucks, particularly SUVs. In 2002, the percentage of total vehicle sales accounted for by light trucks was 58% for GM, 65% for Ford, and 76% for Chrysler.[60] Most premium American SUVs generate profits between $5,000 and $15,000 per vehicle, while highly profitable lines such as the Lincoln Navigator and the Cadillac Escalade can generate up to $20,000. The optional accessories package on a Hummer H2 has an average profit margin of $1,300, which helps overall profitability.[61] Overall, though, the profit margins for the auto industry are slim compared with other industries (See Table 3-10). Table 3-11 summarizes select automaker financial statistics and number of airbags during the period of 1988 to 1997 when automakers introduced airbags across their entire vehicle lines to satisfy the regulation. The ratio of corporate revenue to profits illustrates the thin profit margins in the auto industry, but also the enormous revenues the industry generates.

Table 3-10 Average Profit Margins for a Number of Industries

Industry	Net Profit Margins
Automobile & Truck Manufacturing	**1.43%**
Mobile Homes & RVs	5.66%
Aerospace & Defense	5.79%
Computer Networks	6.44%
Insurance (Life)	9.17%
Computer Hardware	9.38%
Healthcare Facilities	9.88%
Waste Management Services	10.90%
Office Supplies	12.63%
Motion Pictures	15.71%
Biotechnology & Drugs	19.28%
Software & Programming	27.68%

Source: Reuters Investor Website, See:
http://cnnfn.investor.reuters.com/Home.aspx?target=%2f&page=home

Table 3-11 Summary of Financial and Airbag Statistics for Select Automakers (1988-1997)

Auto-maker	Statistics	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1988-1997
Chrysler	Driv. AirBag	58,730	144,912	653,536	603,125	537,761	521,403	341,823	48,316	46,355	32,565	**2,988,526**
	Dual Airbag	0	0	0	0	0	168,645	458,297	770,669	757,841	770,222	**2,925,674**
	Net Revenue	$34,421	$31,039	$26,965	$26,707	$33,409	$41,247	$49,534	$49,747	$58,004	$56,967	**408,040**
	Net Profit	$1,050	$359	$68	($795)	$723	($2,551)	$3,713	$2,025	$3,529	$2,805	**10,926**
Ford	Driv. AirBag	13,471	223,455	770,305	879,240	707,195	552,411	346,357	0	0	0	**3,492,434**
	Dual Airbag	0	0	0	0	284,124	625,119	1,232,702	1,941,570	1,491,167	1,674,107	**7,248,789**
	Net Revenue	$92,446	$82,879	$81,844	$72,050	$84,407	$91,568	$107,137	$110,496	$118,023	$122,935	**963,785**
	Net Profit	$5,300	$3,175	$99	($3,186)	($8,628)	$940	$3,824	$2,056	$1,655	$4,714	**9,949**
GM	Driv. AirBag	2,896	276,190	416,648	917,965	1,031,246	1,385,698	1,263,420	823,653	408,346	113,444	**6,639,506**
	Dual Airbag	0	0	0	0	19,488	161,570	1,191,766	2,331,314	2,298,506	2,532,303	**8,534,947**
	Net Revenue	$123,642	$112,533	$110,797	$109,157	$118,572	$125,253	$141,576	$143,754	$145,427	$153,781	**1,284,492**
	Net Profit	$4,856	$4,224	($1,986)	($4,661)	($23,498)	$2,466	$4,901	$6,881	$4,963	$6,698	**4,844**
BIG 3 Total	Driv. AirBag	75,097	644,557	1,840,489	2,400,330	2,276,202	2,459,512	1,951,600	871,969	454,701	146,009	**13,120,466**
	Dual Airbag	0	0	0	0	303,612	955,334	2,882,765	5,043,553	4,547,514	4,976,632	**18,709,410**
	Net Revenue	$250,509	$226,451	$219,606	$207,914	$236,388	$258,068	$298,247	$303,997	$321,454	$333,683	**2,656,317**
	Net Profit	$11,206	$7,758	($1,819)	($8,642)	($31,403)	$855	$14,418	$9,044	$11,882	$12,363	**25,662**
Toyota	Driv. AirBag	0	0	61,422	144,726	407,498	229,403	12,240	5,700	0	0	**860,989**
	Dual Airbag	0	0	0	0	0	62,038	644,420	768,197	782,296	836,651	**3,093,602**
	Net Revenue	NA	$61,440	$59,962	$71,731	$80,128	$95,063	$91,317	$89,715	$101,177	$99,730	**750,263**
	Net Profit	NA	$2,652	$2,878	$3,140	$1,875	$1,643	$1,227	$1,458	$2,426	$3,143	**20,442**
VW	Driv. AirBag	0	1,490	31,864	13,174	18,195	8,501	0	0	0	0	**73,224**
	Dual Airbag	0	0	0	0	0	7,784	61,669	128,440	156,681	173,037	**527,611**
	Net Revenue	NA	$37,606	$45,429	$48,826	$53,977	$44,774	$50,930	$61,168	$64,491	$63,664	**470,865**
	Net Profit	NA	$597	$725	$713	$93	($1,134)	$95	$233	$437	$765	**2,524**

Source: Ward's Automotive Yearbook 2002, Compiled from annual company reports. **Table Notes:** Revenue and Profit are reported in $2001 and represent global figures. Airbag statistics are for the U.S. vehicle market only.

3.5 Marketing Compliance-Related Vehicle Attribute Changes

3.5.1 Advertising the Airbag

After years of fighting proposed regulation that would require airbag systems, many in the auto industry did an about face and embraced airbag technology as a desirable safety feature. The most dramatic illustration of this reversal is Lee Iacocca who, as president of Ford in the 1970s, fought vigorously against the adoption of an airbag rule on the grounds of cost and the difficulty of competing with import automakers. Then, as CEO of Chrysler Corporation in the late 1980s, he committed to airbags before regulation required such a committal, and before the consumer demand and acceptance of airbags was clear. In 1988, it was reported that manufacturers and dealers, who understandably found risk of injury and death an unattractive item to market, had yet to actively promote the safety technology.[62] Until fairly recently it was not automakers who advertised the airbag most directly, but rather auto insurers and suppliers. The importance of advertising in the overall corporate marketing strategy cannot be dismissed. Automakers support dealers through extensive advertising and promotional campaigns. As a whole, automakers led all other industries in spending on broadcast, print, and billboard advertising in the U.S, with total expenditures of $7.43 billion in 1998, up from $6.79 and $5.74 billion in 1997 and 1996.[63] GM alone spent $2.94 billion on advertising, or about $643 per passenger vehicle it sold that year. In addition to these advertising expenditures, carmakers also spent an average of $2,000 per vehicle in rebates and other incentives to both consumers and dealers in 1998, costing the industry more than $30 billion.[64] The trend toward more generous rebates has continued to the present time.

3.5.2 Early Efforts by Mercedes-Benz

Mercedes-Benz was the first prominent automaker to include airbags in its marketing pitch as part of an overall safety and superior engineering and design campaign. The company slogan used in their advertising at the time was in fact, “Engineered like no other car in the world,” and the inclusion of airbag technology, which during the timeframe of 1984-85 was unavailable from any other manufacturer, was a case in point of the slogan. The automaker’s advertising focused heavily on safety including the company’s anti-lock braking systems (ABS), and the patented supplemental restraint system (SRS), which included an airbag system. The ads involved test track and laboratory settings that further emphasized the company’s professed scientific and engineering prowess.

A 1984 television advertisement depicted a series of dummy crash tests that involved an airbag deployment in slow motion. The commercial acts as an educational device for the consumer who may be unfamiliar with the technology, or may have been exposed to disparaging or conflicting reports about airbags in the press and elsewhere. The viewer also takes away the idea that Mercedes is committed to the safety of their vehicles, which had been an expressed corporate objective since the patenting of the passenger safety cell (a safety improvement to a car’s inner compartment) and its requisite marketing in 1951. A later TV commercial from the 1980s shows a lead engineer for Mercedes being interviewed about this revolutionary patent. The tag line is delivered when the engineer explains in his thick German accent that Mercedes has never enforced the patent despite its use by many other automakers because "some things are more important than money." The message directed at the consumer seems to say, "buying a Mercedes-Benz is an extension of you as a thoughtful, caring person." A 1965 television commercial gives a rundown of all the safety features present on a Mercedes, including its shock-absorbing, padded and flexible interior. Once the technology is clearly demonstrated as in the above crash test spots, the 1984 and 1985 commercials frequently mention the availability of an airbag as a standard or optional feature.

3.5.3 The importance of an Effective Marketing Campaign for GM

The role of marketing in introducing future technologies such as ones to reduce GHG emissions is critical to consumer acceptance of those technologies. Looking back at how GM has marketed airbag technology and new vehicles in the past may provide some rules to follow.

Prior to the successful Daimler-Benz airbag marketing campaign was the admittedly failed marketing (or lack thereof) effort behind GM's dual airbag system that the automaker offered on a number of its full-size Cadillacs, Oldsmobiles, and Buicks during the 1974-76 model years. GM had at first promised to produce over a million airbag-equipped cars, but this number was later cut to 150,000. Unfortunately for airbag proponents and GM, the airbag turned out to be a tough sell and the final tally of airbag-equipped cars sold during this time was a little over 10,000. The question arose whether airbags were a tough sell because consumers were not willing to pay for the safety device, or whether GM and its dealers in effect relegated airbags to this lowly standing by not marketing them properly, and even discouraging customers from purchasing the safety devices in certain instances.

Normally dealers are happy to comply with the customer's choice of options, but this simply was not the case for airbags according to a 1976 *Wall Street Journal* article.[19] A survey of car buyers and GM dealers conducted by the newspaper found that many dealers, like the public in general, knew little about the airbag, mentioned the safety option rarely to customers, and often dissuaded interested car buyers from purchasing a car equipped with airbags. The article depicts GM's relationship with the airbag to be an "on-and-off affair, an odd episode in the annals of auto marketing." According to the report, a number of car buyers who were interested in the airbag-equipped car had a difficult and sometimes impossible time locating one from the dealer. Clarence Ditlow, the Executive Director of the Center for Auto Safety, raised the same issue during sworn testimony before a Congressional Subcommittee. Ditlow stated that dealers have to do three things to sell optional equipment: 1) Have cars in stock at the dealership to show customers 2) Place advertisements in the TV media and 3) Have a brochure explaining the optional equipment for a consumer to look at in the showroom.[65] During the same hearing, GM responded in writing to the following question posed by the Chairman of the Subcommittee.

> *What did General Motors do to promote the air bag cars it sold between 1974 and 1976? Did you promote the airbag through advertising on television, in magazines, through incentives to the dealers, through packaging with other options? What percentage of your dealers had a*

significant supply of cars with air bags in stock on their lots? How does the marketing of the air bag during this period compare with the air conditioner and the automatic transmission when these items were first offered as options in your cars?

General Motors' response:

General Motors provided a 10-minute film presentation showing the operation and potential restraint provided by the air bag system to all Cadillac, Buick and Oldsmobile dealers. This film could be shown by the dealers in the "mini theaters" which General Motors used at the time to provide information to customers on a wide variety of products.

In addition, General Motors placed a newspaper advertisement in the top 20 markets in the United States as well as in national news publications. This full-page advertisement centered on the availability of the air bag option and invited prospective buyers to visit General Motors' dealerships to obtain additional information. It should be noted that, in addition to these efforts, the air bag was offered at a price substantially below its actual cost to General Motors.

Data are not available as to the supply of cars with air bags in dealer stocks during the 1974-76 period, nor are specific data available which compare the marketing effort for air bags with that of air conditioners and automatic transmissions when first offered.[65] (pp.342-3)

Clearly, there was a large discrepancy between GM's characterization of their marketing effort and how it was perceived by airbag proponents. A GM study at the time concluded the many car buyers at the time thought airbags to be a desired attribute.[66]

GM has also had its share of successful marketing campaigns. GM introduced its mid-sized Cadillac Catera in the 1997 model year. The Cadillac market had traditionally consisted of older, loyal customers, but such a market showed little chance for growth. The Catera was designed to grow and diversify the Cadillac market by competing in one of the fastest growing vehicle segments, the entry-level luxury car. Cadillac dealers had to develop new strategies to sell a car to untraditional Cadillac car buyers. Along with a number of standard dealer incentives, GM included an educational component to the marketing campaign, coined Catera College. The college consisted of two ½-day sessions to teach dealers and managers about the new customer base and the issues surrounding the vehicle.[67] Dealers drove the car and saw it taken apart piece by piece in an effort to learn the selling points of the car. The dealers were also taught the demographics and characteristics of the market segment relevant to the Catera. The dealers were reported to be enthusiastic about the training program because it was an opportunity to increase their sales. GM has used similar marketing practices to introduce new vehicles and options, but the cooperation and enthusiasm of the dealers is necessary for a successful program. This was the key ingredient missing with the initial airbag campaign.

3.5.4 Ford and Chrysler Follow Mercedes' Lead in Different Ways

Ford Motor Co. followed shortly after Mercedes-Benz to become the only domestic automaker to offer an optional airbag for the 1986 model year. The company had already sold over 5,000 airbag-equipped Tempos to the Federal government, which helped to jumpstart their commercial airbag program. Ford received some of the same criticism GM had had to endure in the 1970s. It was reported in *The Wall Street Journal* that car buyers faced stiff opposition from Ford and its dealers when requesting the airbag option.[68] The cause for this resistance may have been concerns over liability and perhaps a deliberate limited supply of airbags. Ford contended at the time that the company was losing money on the $815 option.

In 1988, Chrysler boldly announced that it would equip all of its new cars with driver-side airbags by 1990.[69] The marketing campaign that followed was unprecedented in its dramatic push for airbags. The advertising was handled by the Bozell firm, which developed a cascade of television commercials in 1990. A series of these television commercials involved Lee Iacocca sitting across from a person who had survived a horrific automobile accident presumably because of the timely airbag deployment in their Chrysler vehicle. The commercials have a personal quality rarely seen in automobile advertising with the name and place of residence of the accident survivors given visually at the start of the spot. The first of these featured Karen McGowan from Columbia, Maryland, who was able to refuse emergency medical care after her Chrysler LeBaron crashed head-on into a tree. She exclaims, "luck had nothing to do with it, that airbag saved my life." Iacocca ends the commercial by saying, "I could give you a dozen reasons why you should consider a Chrysler product, but today I will give you just one: Karen McGowan." McGowan's personal account of the accident is stirring because it is a near-death experience related from someone who strongly believes an airbag is the sole reason she is still alive. Similar commercials include a reverend and a pair of married couples, all of whom are presented as ordinary people who could be your neighbor. These testimonials helped to depict the airbag as a life-saving device that nobody should be without.

Another memorable commercial has a stuntman pick up and throw a crash test dummy out of a Chrysler car. The stuntman next occupies the car, fastens his seatbelt and proceeds to drive into a fixed barrier at 21 mph, which activates the airbag. A close-up of the stuntman safely striking the airbag is shown in slow motion followed by his nonchalant exiting of the vehicle. Such a test is meant to further build consumer confidence in the new airbag technology. Where in the past, Mercedes showed a dummy colliding with an airbag; Chrysler upped the ante by showing an actual person. Yet another television spot reconstructs an historic post-collision scene on a rural road in Virginia. This is the first reported collision between airbag-equipped vehicles where two Chrysler LeBarons collided head-on and both drivers survived with only minor injuries. Chrysler seized this serendipitous accident to create a powerful commercial. The poignancy of these commercials is punctuated by the fact that Chrysler was the only domestic or Japanese automaker to include airbags on the majority of its passenger car line, as Iacocca is quick to point out in the commercials. Iacocca shrewdly recognized that the airbag could be an easy way to differentiate his company's product from the competition.

A shift was also taking place in the marketplace toward greater consumer valuation of safety features. Bob Munson, director of Ford's auto safety office, summed this up in 1989 – "Our market studies show in the past three years, safety more and more has become an issue that affects what product people buy."[70] The old auto-marketing adage that "safety doesn't sell" was no longer applicable. No other automaker used the airbag as a focal point in the way Chrysler had, but more and more advertisements over the course of the early 1990s mentioned the airbag, thus positioning the safety device as a marketing tool. European automakers such as Volvo, Mercedes, and Saab continued their long-standing tradition of actively promoting safety features, but now they were joined by a host of American and Japanese automakers as well. Toyota marketed their Previa by offering the "43 Best Reasons" for driving the minivan – its conformity to 43 federal car safety standards. Ford capitalized on the availability of dual airbags by featuring the safety devices prominently in its ads for the company's flagship passenger car, the Taurus. General Motors, which lagged behind Ford and Chrysler, focused its safety marketing on ABS, which helped distinguish GM from its competitors. Virtually every automaker helped promote the introduction of airbags into their vehicle lines through advertising.

3.5.5 Negative Portrayals of Airbags in Automakers' Marketing

Throughout the 1970s and into 80s many factions in the auto industry claimed that airbags were dangerous, would be impossible to test in time to implement, were not the most cost effective way to reach the objective of lower motor vehicle fatality and injury rates, and were susceptible to inadvertent deployment. A Ford advertisement raised the prospect of "driving along at 60 mph and suddenly having an enormous pillow thrust in your face." NHTSA and safety groups insisted that such an incident had never occurred in millions of miles of testing. GM and Volvo among other automakers warned of the dangers of out-of-place occupants and children. These latter warnings proved to be true when a number of deaths were caused by airbags inflating in low severity crashes. From 1990 until 2003 231 such deaths reportedly occurred. These deaths included 79 drivers, 10 adult passengers, 119 children, and 23 infants. In the midst of the bad press generated from these reports, the automakers and other corporations formed a coalition called the Air Bag Safety Campaign, which among other educational initiatives produced advertisements promoting airbag safety, including the one shown in Figure 3-6. In addition, automakers responded vigorously. For instance, Volvo Cars of North America ran TV ads encouraging parents to put their children in the backseat, GM sent letters to 7 million of its vehicle owners and ran a host of radio spots, and Chrysler Corp. started its own airbag safety mail campaign.[71]

Figure 3-6 Big 3 Automaker Advertisement on Airbag Safety (1997)

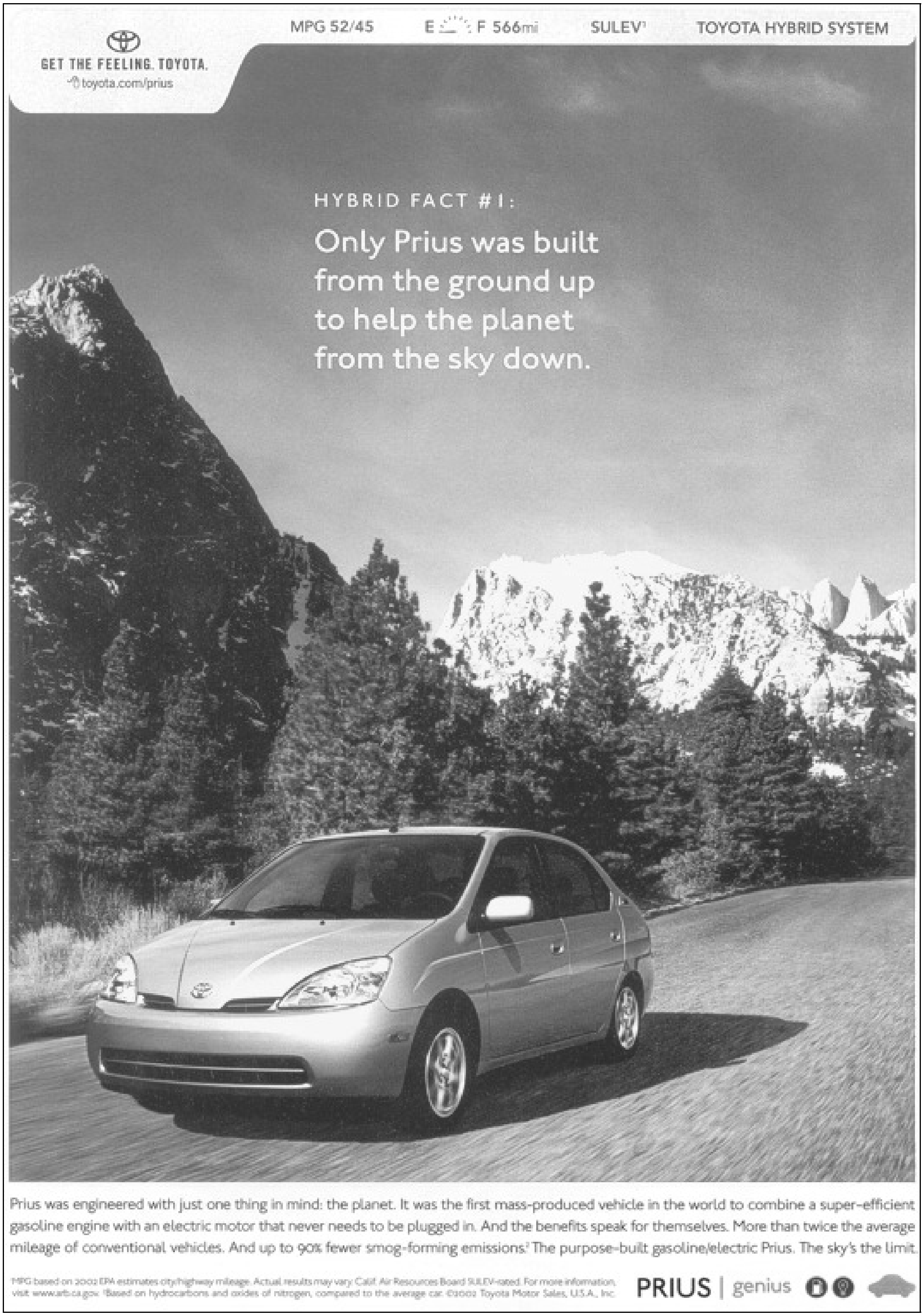
3.5.6 Implications for Marketing Technologies that could reduce GHG Emissions

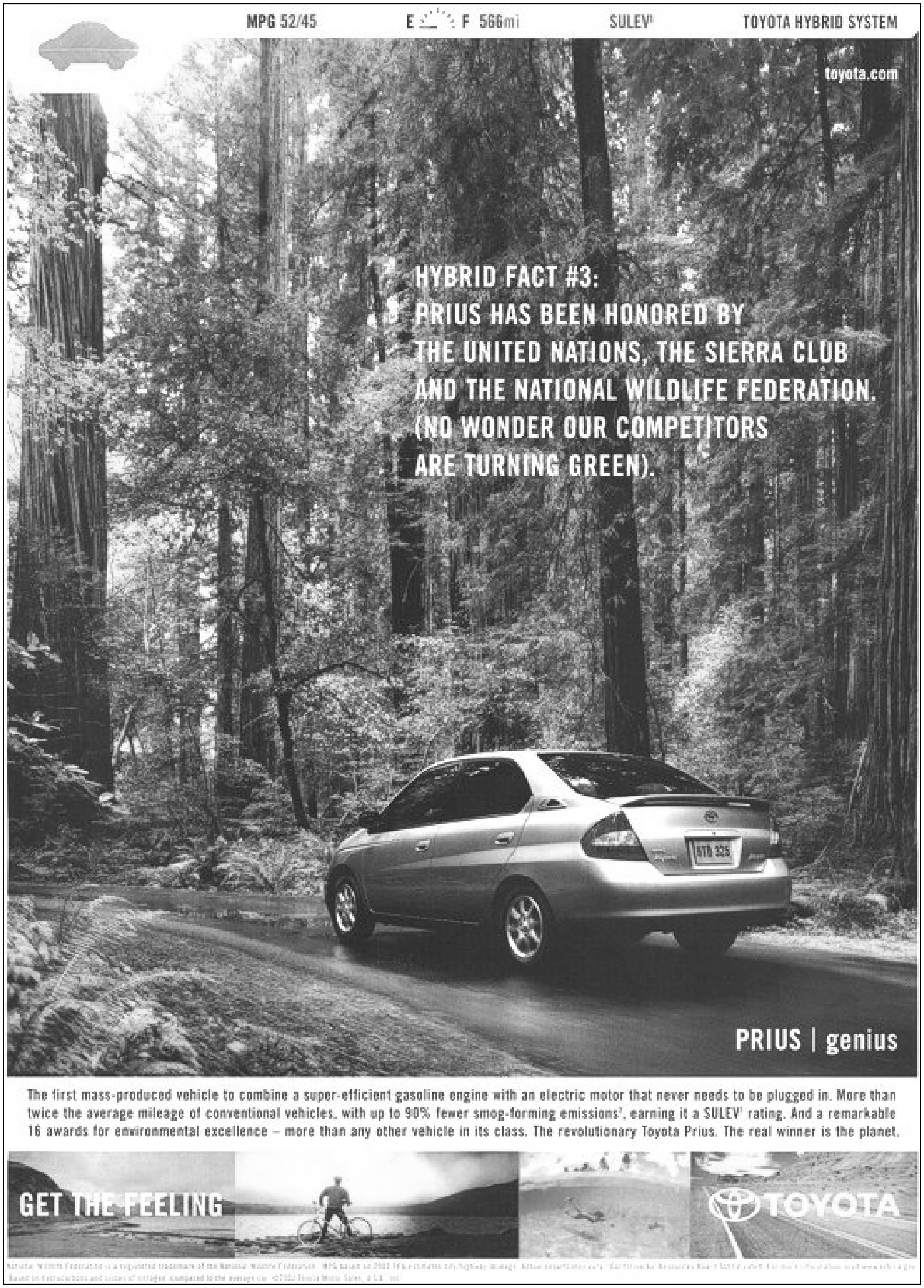
Just as automakers effectively marketed safety and airbags, they can market technologies and models that reduce greenhouse gas emissions. Currently, there is no greenhouse gas legislation in place, but some automakers are already voluntarily marketing technologies that could play a significant role in response to future regulation.

Volkswagen, for example, launched an advertising campaign in support of its diesel-powered cars in 2002. The campaign, which consisted of print ads and 30-second TV commercials, was the first of its kind since the company reintroduced diesels into the American market six years earlier. The advertisements touted the vehicles TDI engine and low fuel consumption, but do not reveal that TDI stands for Turbo Diesel Injection.[72] VW must have felt that promoting the fuel economy improvement that the technology created was a more effective strategy than marketing the technology itself. This strategy is also likely an attempt to enhance the reputation of diesel engines in the US passenger vehicle market.

Hybrid electric vehicle technology has also been marketed relatively extensively during the advanced technology's early entrance into the marketplace. While both Toyota and Honda offered HEVs in the early years of this decade, Toyota has marketed its Prius much more aggressively than Honda has its Civic and Insight. For the first two generations of the Prius, there have been no fewer than 12 unique television commercials, clever Internet advertisements and dozens of print ads appearing in an assortment of well-read periodicals (See Figures 3-7 and 3-8 for example). The ads consistently tout the technology and the environmental friendliness (high fuel economy and low emissions) resulting from the hybrid system, in addition to typical selling points such as comfort and convenience attributes. The ads for the second generation Prius have stressed 'private good' features to a greater extent than those of the previous generation, but have maintained the importance of the 'public good' attributes at the same time. This may signify a shift in the target population from a niche market of early-adopters and technology enthusiasts to a more general, much larger market base. Ernest Bastien, marketing manager for Toyota Motor Sales USA, has confirmed that Prius advertising will be aimed at general audiences, not just environmental activists and technology buffs.[73] The verdict is still out on the question of consumer acceptance of environmentally friendly vehicles. "It's too complicated right now for (consumers) to understand," said the senior automotive analyst for Forrester Research, Mark Bünger. "I hope we'll get a better branding of the vehicles, à la Energy Star or Intel Inside – some real simple stamp that will tell people they're getting a good thing."[74] The Toyota Prius advertising has focused its attention on developing a simple branding to help identify the environmentally-friendly cars in the cluttered new car marketplace.

Figure 3-7 First Generation Toyota Prius Ads (c. 2000)




MPG 52/45
E F 566mi
SULEV
TOYOTA HYBRID SYSTEM
toyota.com
HYBRID FACT #3:
PRIUS HAS BEEN HONORED BY
THE UNITED NATIONS, THE SIERRA CLUB
AND THE NATIONAL WILDLIFE FEDERATION.
(NO WONDER OUR COMPETITORS
ARE TURNING GREEN).
PRIUS | genius
The first mass-produced vehicle to combine a super-efficient gasoline engine with an electric motor that never needs to be plugged in. More than twice the average mileage of conventional vehicles, with up to 90% fewer smog-forming emissions, earning it a SULEV rating. And a remarkable 16 awards for environmental excellence – more than any other vehicle in its class. The revolutionary Toyota Prius. The real winner is the planet.
GET THE FEELING
TOYOTA

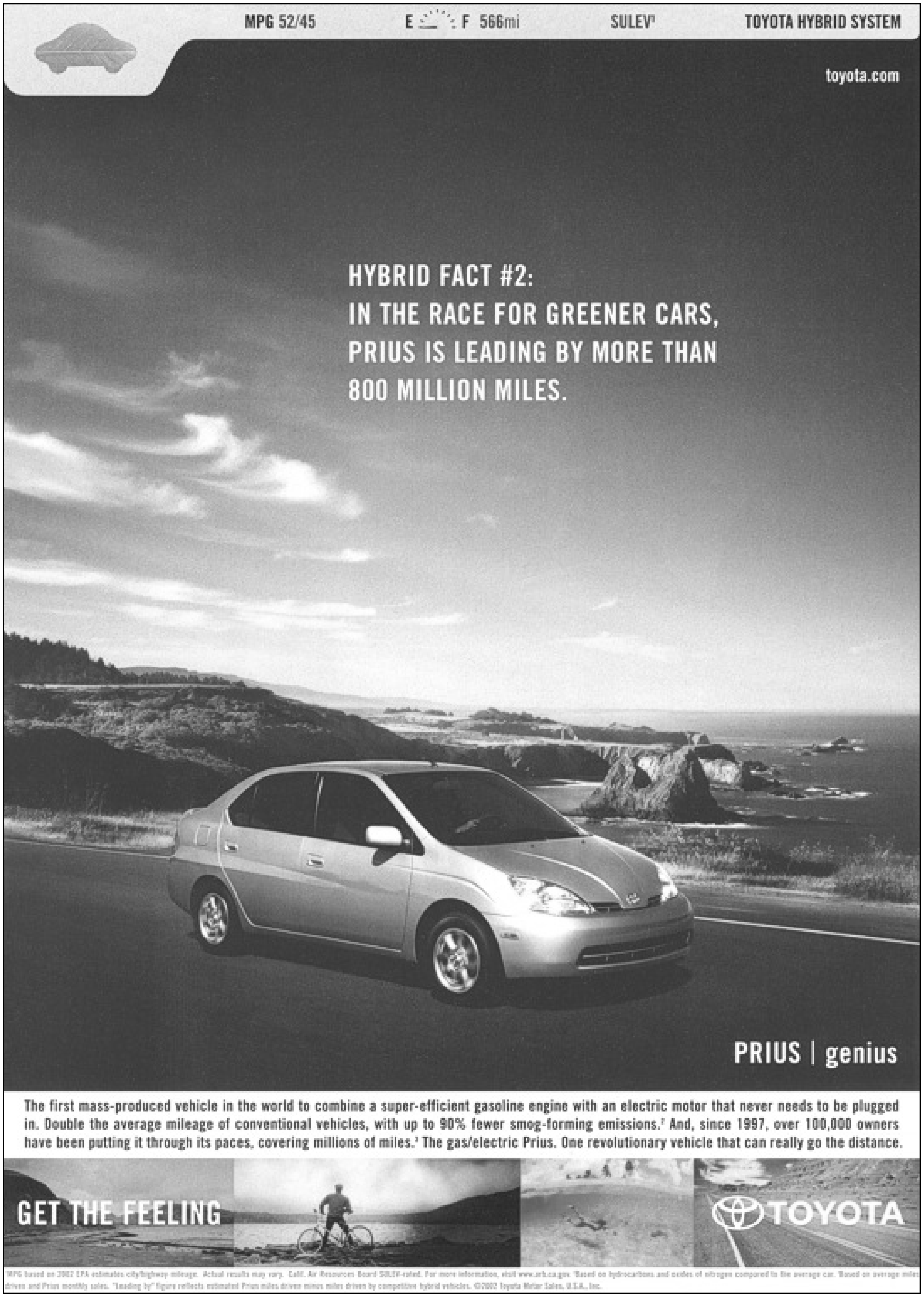
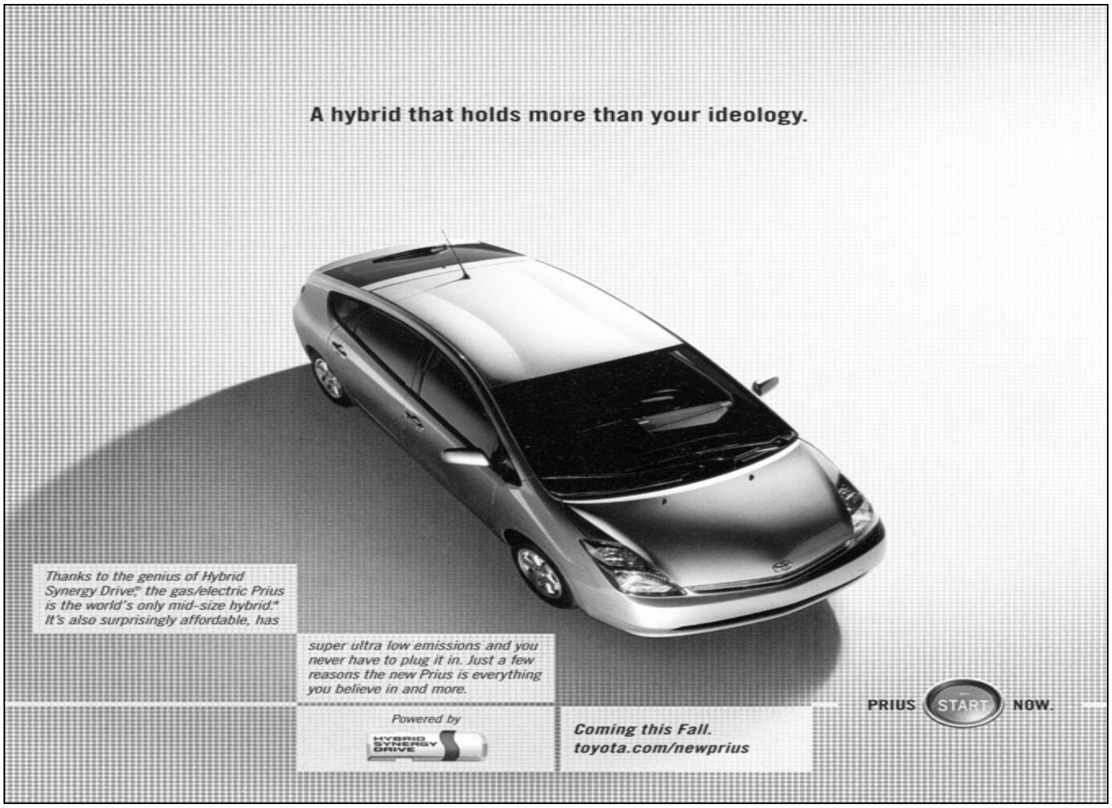

MPG 52/45
E F 566mi
SULEV[1]
TOYOTA HYBRID SYSTEM
toyota.com
HYBRID FACT #2:
IN THE RACE FOR GREENER CARS,
PRIUS IS LEADING BY MORE THAN
800 MILLION MILES.
PRIUS | genius
The first mass-produced vehicle in the world to combine a super-efficient gasoline engine with an electric motor that never needs to be plugged in. Double the average mileage of conventional vehicles, with up to 90% fewer smog-forming emissions.[2] And, since 1997, over 100,000 owners have been putting it through its paces, covering millions of miles.[3] The gas/electric Prius. One revolutionary vehicle that can really go the distance.
GET THE FEELING
TOYOTA
MPG based on 2002 EPA estimates city/highway mileage. Actual results may vary. [1]Calif. Air Resources Board SULEV-rated. For more information, visit www.arb.ca.gov. [2]Based on hydrocarbons and oxides of nitrogen compared to the average car. [3]Based on average miles driven and Prius monthly sales. "Leading by" figure reflects estimated Prius miles driven minus miles driven by competitive hybrid vehicles. ©2002 Toyota Motor Sales, U.S.A., Inc.

Figure 3-8 Second Generation Prius Ads (c. 2003)



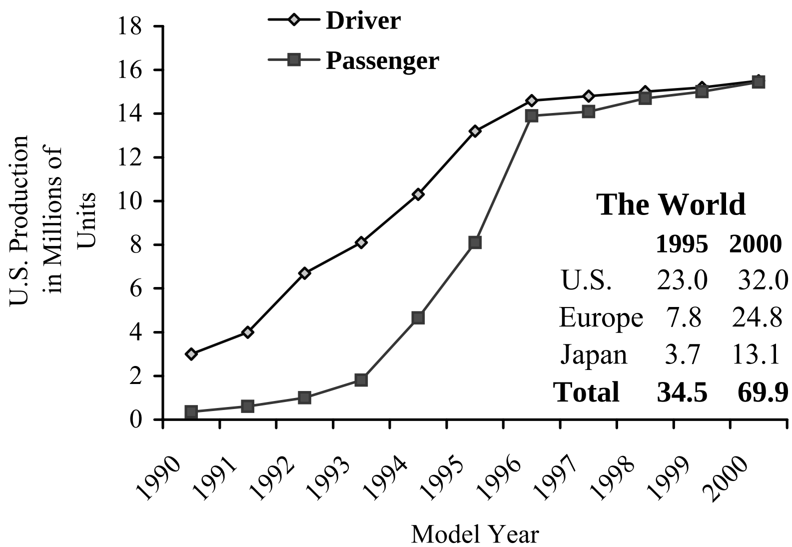

Introducing
high performance technology
that's also
good
for the environment.
In the race for a greener planet, Toyota is determined to win. That's why we've developed Hybrid Synergy Drive,* a revolutionary power train that combines a gasoline engine with a powerful electric motor that never needs to be plugged in.
The result? Super-efficient, super-charged performance.
Hybrid Synergy Drive achieves nearly 2.5 times the average fuel efficiency of conventional vehicles and close to 90% fewer smog-forming emissions – all while dramatically boosting power.* In fact, Hybrid Synergy Drive can inject a V6 SUV with the power and torque of a V8.
This groundbreaking yet affordable technology will hit the roads this fall in the next generation Prius. After that, Hybrid Synergy Drive will be available in more and more Toyota products. Welcome to a new era in driving – we're off and racing.
toyota.com/tomorrow
*Manufacturer's testing for 2004 est. city & combined mpg. ©2003
HYBRID SYNERGY DRIVE
TODAY TOMORROW TOYOTA

3.6 BUSINESS, JOB, WEALTH CREATION RESULTING FROM COMPLIANCE

3.6.1 Expansion of the Automotive Airbag Industry

The years following the legislation requiring airbags have been very active ones for the occupant restraints industry. Figure 3-9 highlights the growth of the airbag industry in the decade of the 1990s. Figure 3-9 also shows how the rapid growth in airbag production at home led to swift growth abroad where no such occupant regulations were in effect. There were slightly over 2 million driver and passenger frontal airbag units combined on 1990 model year cars sold in the U.S., and by the 1998 model year when the regulation became fully enacted, there were roughly 18 million dual airbag units.

Figure 3-9 Growth in Airbag Production in Millions (1990 to 2000)



The World

	1995	2000
U.S.	23.0	32.0
Europe	7.8	24.8
Japan	3.7	13.1
Total	**34.5**	**69.9**

Source: Ward's Automotive Yearbook (Various Years)

Several major airbag companies have merged with or acquired other key participants, resulting in a consolidation of the industry. Allied Signal sold its seatbelt and airbag division to BREED in 1997. As a result, BREED now competes in the occupant restraints market as a supplier of inflators, cushions, airbag modules, collision sensors, electronic control units, occupant sensing systems, steering wheels, seats and seatbelt systems. Magna competed in the occupant restraints industry through MST Automotive, and produced inflators, airbag modules, steering wheels, and seatbelt systems. Early in 1998, TRW purchased from Magna all remaining equity in the MST operations, making it a fully owned division of TRW. Morton International competed in the industry through the Automotive Safety Products division (APS), and was a leading supplier of inflators, modules, and cushions. On May 1, 1997, Morton sold its Automotive Safety Products division to Autoliv AB to form a new company, Autoliv, Inc. In purchasing the ASP division of Morton, Autoliv is now the leading supplier of airbag inflators in the world. Autoliv AB had formed in 1991 through the merger of

Europe's leading automotive safety company and the leading airbag company at the time in the U.S. Table 3-12 shows the current global and domestic situations respectively for the largest airbag suppliers. While the airbag industry is very much a global business, the domestic industry has grown tremendously as well. Three of the top five airbag suppliers (TRW, Delphi, and Breed) are located in the U.S. Takata is based out of Japan, but has major American operations, as does Autoliv.

Table 3-12 Shares in the Global and US automotive safety equip. markets, 2000 (US$ market value)

	Domestic		Global	
Manufacturer	**Seatbelts (%)**	**Airbags (%)**	**Seatbelts (%)**	**Airbags (%)**
TRW	40	30	29	26
Autoliv (inc NSK)	12	33	30	35
Takata	15	5	17	15
Delphi	0	17	0	11
Breed	25	6	14	4
Others	8	9	10	9
Total	100	100	100	100

Sources: www.just-auto.com and industry estimates

As shown in the tables, Autoliv controls the largest percentage of both the US and global airbag markets. Financial information for Autoliv in the form of SEC 10-K filings and annual company reports was available to a much greater extent than all of the other major airbag suppliers other than Delphi, which is a vast company where airbags plays a minor role in the overall company. For this reason, Autoliv was chosen to be more closely analyzed. Autoliv deals exclusively with occupant protection and vehicle safety systems, and airbags are the single most important product the company offers. Table 3-13 shows the tremendous growth of Autoliv during the period of 1993-2002. This table illustrates the creation of a new and important industry, resulting from the regulatory compliance process.

Table 3-13 Summary of the Expansion of Autoliv (Airbag Supplier)

Year	Airbag Sales (Millions USD)	Net Income (Millions USD)	Earnings Per Share	Number of Employees[1]	# Airbag units sold[2]
1993	$164	$16	$0.38	4,405	-
1994	$534	$56	$1.05	5,740	3,100,000
1995	$682	$91	$1.66	6,670	4,920,000
1996[3]	$2,287	$174	$1.69	9,000	6,100,000
1997	$2,317	$185	$1.81	17,800	20,500,000
1998	$2,417	$188	$1.84	20,700	28,200,000
1999	$2,715	$200	$1.95	22,600	37,000,000
2000	$2,934	$169	$1.67	28,000	43,500,000
2001[4]	$2,817	$48	$0.49	31,800	42,195,000
2002	$3,160	$181	$1.84	34,200	51,000,000

Source: Autoliv Inc., Annual Reports, See: http://www.autoliv.com/appl_alv/Autoliv.nsf/pages/financial_annual
Table Notes: 1- Number of employees globally, The number of US employees in 2002 was nearly 8,000**.** **2** – Total number of airbag assemblages sold including side airbags and curtains. **3** – Autoliv merged with large airbag supplier, Morton, **4 –** Restructuring year due to merger.

The passage below, which describes the company's approach to achieving cost-competitiveness, is taken from the 2002 Autoliv Annual Report.

> The most important action is redesign of our safety systems by introducing, for instance, more cost-efficient inflators in our airbag systems, replacing labor-intensive cut-and-sewn airbag cushions with one-piece-woven airbag cushions, re-sourcing of labor-intensive products in low labor-cost countries, and replacing steel with reinforced plastics in the housings of the airbags. Vertical integration is another effective tool in our cost reduction program. In 1998, for instance, we increased substantially the annual production capacity for airbag initiators at NCS, a supplier which we acquired in 1996.

Figure 3-10 shows that that airbags have fueled Autoliv's large expansion over the last decade. The market for seatbelts has flattened, while the increase in airbags and electronics and the recent introduction of side airbags, have been fueling the expansion of the company.

Figure 3-10 Market by Product for Autoliv (1993-2002)

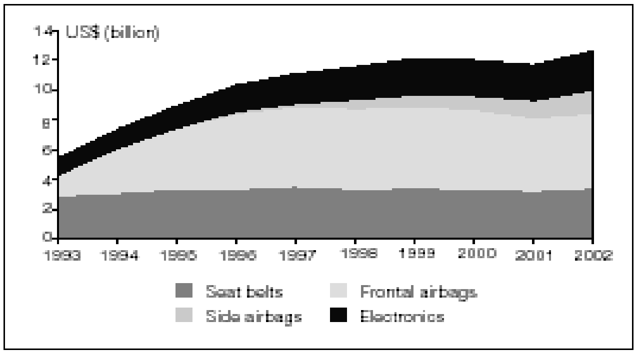
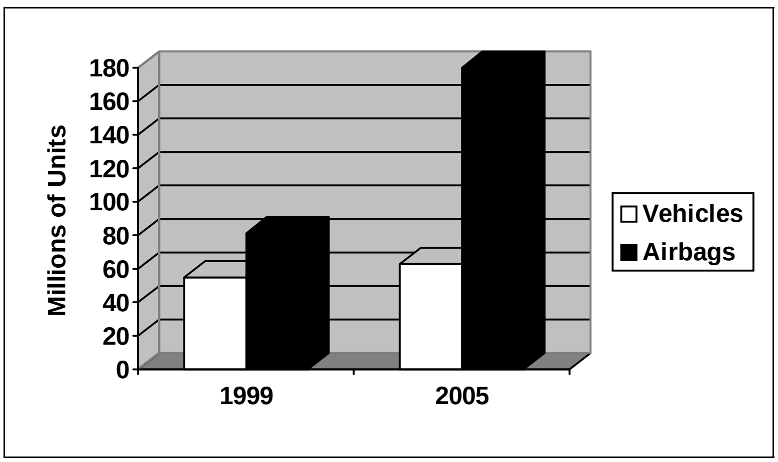


Figure 3-11 indicates the continuing growth in the airbag market. The average number of airbags installed per vehicle is expected to nearly triple between 1999 and 2005 in the global automotive market. As of 2001, the $12 billion vehicle occupant restraint market had grown by an average rate of 12% annually since 1993.[75] While the catalyst behind the initial expansion of the airbag industry was federal safety regulation in the U.S., the continued growth of the industry has relied on consumer demand, improvements in safety technology and innovative new products.

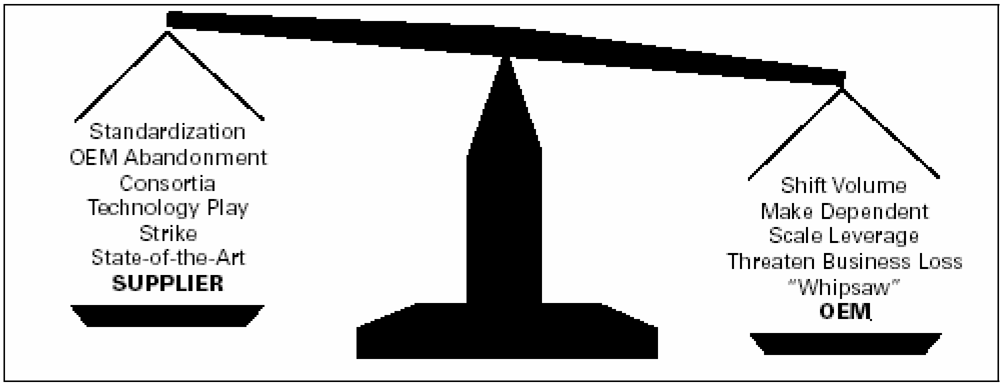
Figure 3-11 Global Outlook for Airbag Industry (1999-2005)



Source: Price Waterhouse Cooper, AUTOFACTS, 2003. http://www.autofacts.com/index.html

Airbag suppliers are held 'captive' by the great purchasing power of the OEMs. The Autoliv 2002 Annual Report states that pricing pressure from their customers, the automakers, is an inherent part of the automotive components business. It was reported that the boom the airbag industry experienced was unlikely to translate into big profits for companies such as TRW, Autoliv, Takata Corp. and Breed Technologies Inc. Morris Kindig, president of the research company Tier One, affirmed that competition and pricing pressure from automaker customers keeps profit margins low. He stated that like most major automotive suppliers, "everyone is really struggling for profitability."[76] The graphic in Figure 3-12 illustrates the balance of power between the OEMs and automotive suppliers.

Figure 3-12 Balance of Power Illustration between OEMs and Suppliers



Source: Ernst & Young, LLP, "Profile of Tomorrow's Automotive Supplier" http://www.autoindustria.com/encuentro/documentos/automotive_supplier_capgemini.pdf

Smaller tier two and tier three suppliers that produce airbag components have also shown rapid growth. For instance, a recent study on the "World Image Sensors Market" from Frost & Sullivan suggests that a growing complementary metal-oxide semiconductor (CMOS) technology market will enhance vehicle safety applications, especially SUV safety, through controlled airbag deployment and collision avoidance systems. The report reveals that the entire image sensor industry generated revenues of $2.4 billion in 2000. Frost & Sullivan projects these revenues to reach $6.5 billion by 2007.[77]

3.6.2 Technological Innovation with respect to Airbags

The research and development expenditures of automakers and suppliers that helped to produce a reliable and cost-competitive safety device were substantial. In response to NHTSA questioning, airbag supplier TRW stated in January 1998 that the company had invested over $1.1 billion ($332 million on R&D alone) in its airbag business over the last decade. According to annual company reports, Autoliv has been spending in the neighborhood of $175-200 million per year on R&D since 1993. Table 3-14 highlights the proliferation in patent issuances since airbag regulation took effect. The former Administrator of NHTSA, Joan Claybrook, summarizes the effect regulation can have on technological innovation in the following passage.

> Regulations, in general, encourage innovation in areas where the market demand is unclear. If manufacturers believe safety does not sell, they will be reluctant to risk innovations in that area, believing they will have a price disadvantage if they do. By levying uniform standards on all companies, this risk is eliminated and the manufacturers are challenged to find the least costly way to achieve the performance required.[78]

Claybrook contends that federal emissions, fuel economy and safety standards have stimulated not only product innovation, but have advanced the art of automotive engineering as well. The number of patents is typically used as a proxy measure for technological innovation. Table 3-14 shows that out of the nearly 10,000 automotive airbag relevant patents, over 70% of these have been issued since 1995, and the rate appears to have been accelerating through 2000. Clearly, the primary driver for such a rapid upsurge in airbag technology development was the passive restraint regulation. The regulation provided the impetus that created the initial market.

One of the best examples of successful "technology forcing" regulation involved automotive emission control technologies. The two most glaring technologies to come out of these strict regulations were the simple oxidation catalysts and the closed loop, three-way catalysts with sophisticated on-board feedback control systems, but innovative technologies have continued to meet requirements such as the SULEV and PZEV standards in California, and the National Low Emission Vehicle Program (NLEV) nationwide. Technologies were developed to meet the stringent requirements although automakers were initially pessimistic toward the possibility of even achieving compliance. Lee Iacocca and other industry executives asserted that the 90% emissions reduction requirement "could prevent continued production of automobiles" and "do irreparable damage to the American economy."[79] Figure 3-13 depicts the relationship between the number of patents for automotive emission control technologies and the stringency of emissions regulations

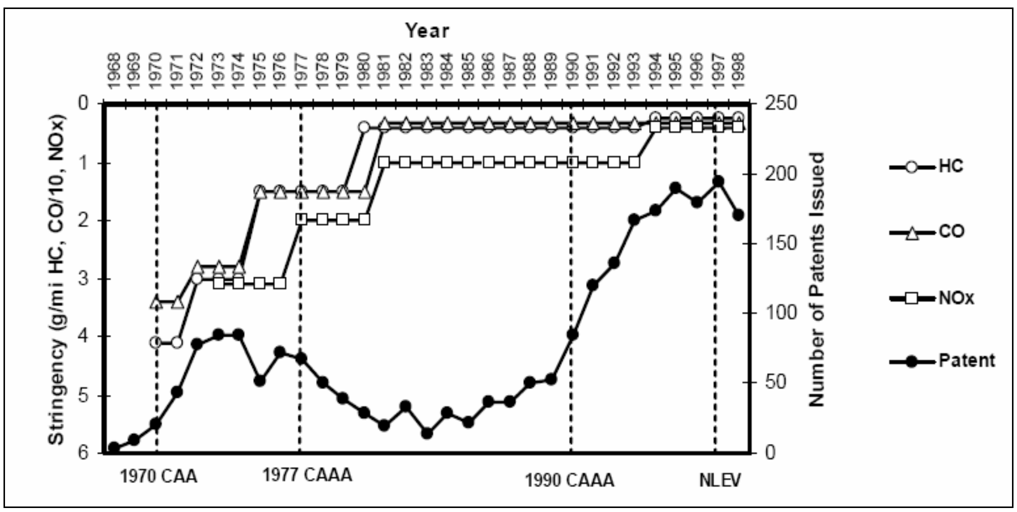
Table 3-14 Relevant patents issued for automotive airbag technology

Patent Subclass	**Pre-1980**	**1980-1989**	**1990-1994**	**1995-1999**	**2000-present**	**Total**
728.1	20	14	58	177	208	**477**
728.2	7	5	96	374	317	**799**
728.3	9	11	117	285	228	**650**
729	33	9	12	43	117	**214**
730.1	48	6	39	110	129	**332**
730.2	4	2	30	196	356	**588**
731	55	32	142	245	206	**680**
732	39	14	161	289	190	**693**
733	51	11	23	33	82	**200**
734	65	25	50	70	76	**286**
735	140	46	179	400	542	**1307**
736	51	18	95	191	205	**560**
737	81	10	43	169	109	**412**
738	26	3	19	22	10	**80**
739	30	7	25	67	66	**195**
740	46	11	44	96	88	**285**
741	90	31	118	357	255	**851**
742	32	6	35	71	126	**270**
743.1	38	7	88	261	283	**677**
743.2	6	2	19	60	105	**192**
Total	**871**	**270**	**1393**	**3516**	**3698**	**9748**

Table Notes: Data compiled from US Patent and Trademark Office, See: http://www.uspto.gov/. The patent subclasses are all under Class 280 – Land Vehicles. A description of the patent subclasses is offered in Appendix E.

In the case of the airbags, some researchers contend that the behavior of the OEMs and airbag suppliers suggests that competition to meet the expected regulatory standard, not competition to satisfy consumer demand, was the primary driver of R&D and innovation with respect to airbag technology.[80] The emissions control and passive restraint regulatory episodes were not driven by differences in costs or complexity of the technological solutions.[80] GM installed airbags on several thousand vehicles in 1973, illustrating that the technology was workable. GM also offered airbags on a number of models between 1974 and 1976, at a price of $235-$315. Field results from these cars and a fleet of Mercurys operated by State Farm Insurance performed well. However, by the end of the decade no automaker was producing airbag-equipped vehicles. In contrast, GM and Ford each put catalytic converters on their vehicles in 1975 at a unit cost of roughly $250 per vehicle, and by the end of the decade virtually all automobiles sold in the U.S. employed catalyst technologies. Clearly, it was the necessity of compliance that assured the adoption of innovative technologies. In the airbag case, the market and the numerous accompanying innovations emerged after regulation signaled the need for airbag technology. The continued path of innovation has been fueled by a combination of both consumer demand and regulation for advanced airbags and airbag systems in general in other countries.

Figure 3-13 Patenting Activities in Automotive Emission Control Technologies, 1968 to 1998



Source: Lee, Jaegul, et al. "Innovation in Automotive Emission Control Technologies: Government Actions, Inventive Activity, and Learning," Proceedings on 7th International Conference on Technology Policy and Innovation, Monterrey, Mexico

3.7 UNREGULATED AUTOMOTIVE SAFETY SYSTEMS

A host of other safety technologies emerged around the time frontal airbags became a fixture in new vehicles. A look at three prominent examples of these technologies will help to place airbags in the overall context of vehicle safety attributes. ABS, traction control and side airbags are the other high-profile safety devices that have been available as optional or standard equipment during, or shortly after, frontal airbags. ABS and traction control are active safety features, while side airbags and airbags in general are considered passive safety features (See Table 3-15 for examples).

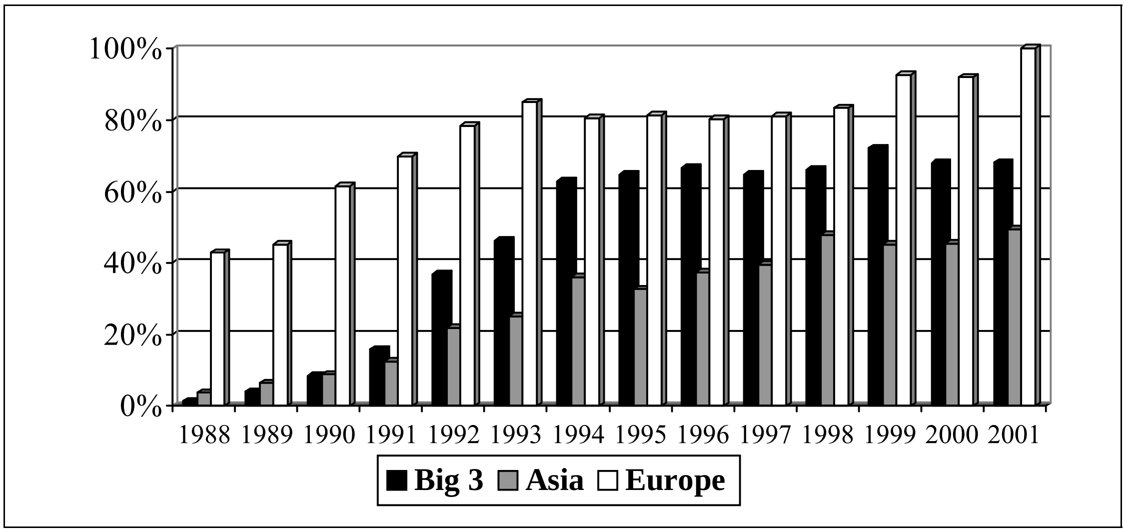
Table 3-15 Examples of Active and Passive Safety Attributes

ACTIVE SAFETY FEATURES (CRASH AVOIDANCE)	PASSIVE SAFETY FEATURES (CRASH WORTHINESS)
Traction Control	Energy Absorbing Structure
Mirror Systems	Hood Latch Systems
Yaw Control Systems	Side Impact Door Structure
Headlamp Lighting Systems	Fuel System Integrity
Visibility	Safety Cage Occupant Compartment
Vehicle Lighting Systems	Interior Impact Protection
Displays & Controls	Compressible Steering Column
Anti-Lock Brakes Systems	Child Restraint Systems
Speed Sensitive Steering Systems	Seat Systems
Adaptive Suspension System	Safety Glazing Systems
Brake Systems	Adjustable Safety Belt Anchorages
Wheel & Tire Systems	3-Point Safety Belts
Wiper/Washer	Locks and Latches
	Load Limiting Safety Belts
	Safety Belt Pretensioner
	Head Restraints

3.7.1 Anti-Lock Braking Systems (ABS)

ABS were originally developed for trains in the early 1900s, and were then adopted by jet aircraft, which demand fast, controlled braking, after World War II.[81] ABS were generally considered to be costlier than airbag systems. While ABS became standard on most luxury cars, particularly European models, as far back as the 1980s, it was GM that pioneered the system's inclusion across an entire vehicle line. The installation rate on GM cars hovered between 80-90% from 1994 to 2001, but GM in a cost-cutting effort eliminated standard ABS and side airbags from most of its vehicles beginning with the 2003 model year. According to GM, ABS, at that time, cost the company about $160 per vehicle, and side airbags were an additional $60.[82] GM had obtained a competitive advantage over its competitors in the early 1990s with its ABS VI system designed by the firm's Delco Chassis Division. Delco engineers through design improvements and other cost-saving measures produced a relatively inexpensive system that could be made standard on even the company's economy cars. Experts at the time predicted that ABS, fueled by consumer demand, would be made standard on almost all cars before the decade was through. According to Figure 3-14 this was true only for the European automakers with the Big Three having leveled off at less than 70%, and Japanese automakers currently installing ABS on only about ½ of the cars they sell in the U.S. Currently, the average cost to consumers for ABS is about $470.[83]

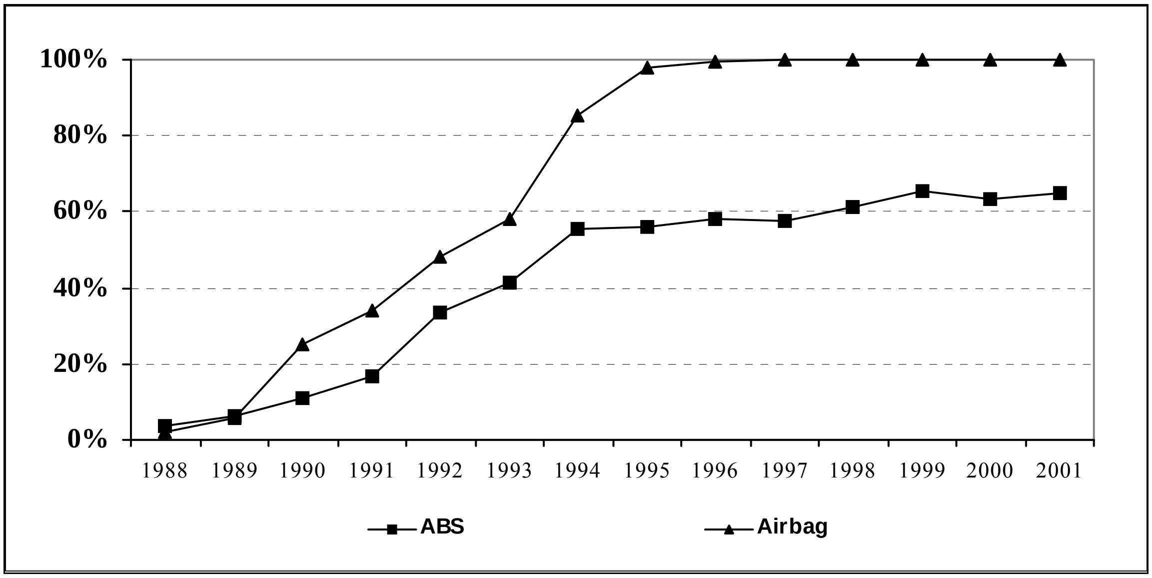
Figure 3-14 Anti-Lock Braking System Installation Rates on Cars Sold in the U.S.



Source: Ward's Automotive Yearbook (Various Years)

Without regulation, would the installation rates for airbags be even with ABS, or more or less? The question cannot be answered with any degree of certainty, but across the board 100% installation rates most likely wouldn't have been achieved without regulations. Figure 3-15 shows the respective installation rates of airbags and ABS on passenger cars sold in the U.S.

Figure 3-15 ABS and Airbag Installation Rates on Passenger Cars Sold in the U.S.

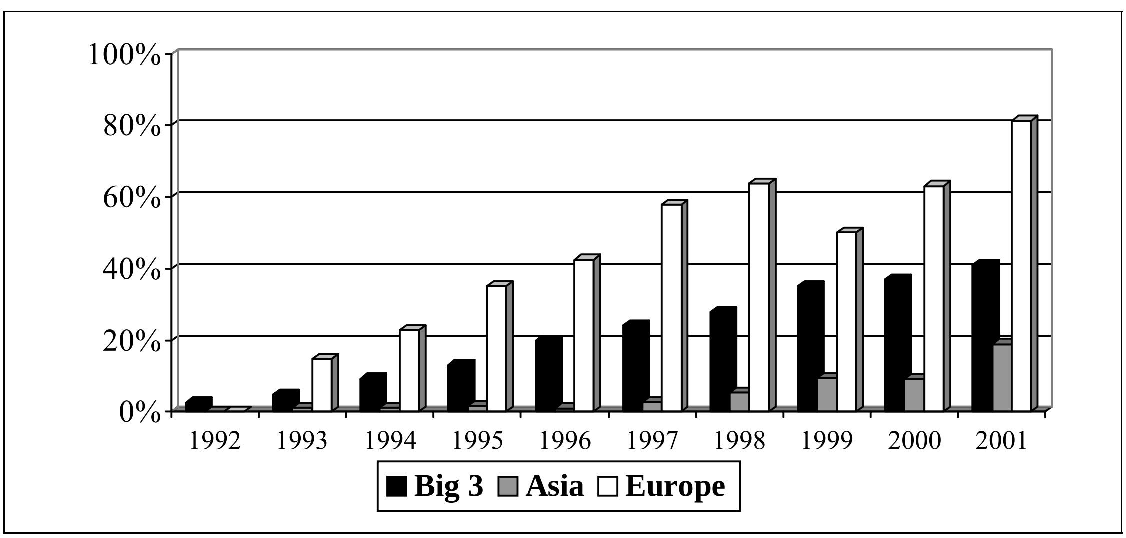


Source: Ward's Automotive Yearbook (Various Years)

3.7.2 Traction Control

Traction control works to prevent unwanted wheel spin in low-traction situations such as snow or rain by adjusting vehicle acceleration. The system maintains the car's *steerability* by detecting when a tire has little traction and then correcting the wheel spin by slowing the wheel's movement.[84] This attribute, like most safety features, has become increasingly popular over the last ten years. The demand for traction control systems is driven entirely by consumer demand with regulatory pressure playing no role in its success. The average cost to consumers for a typical traction control system is currently about $220.[83] Figure 3-16 shows how rapidly traction control systems have penetrated into the U.S. passenger car market.

Figure 3-16 Traction Control Installation Rates on Cars Sold in the U.S.

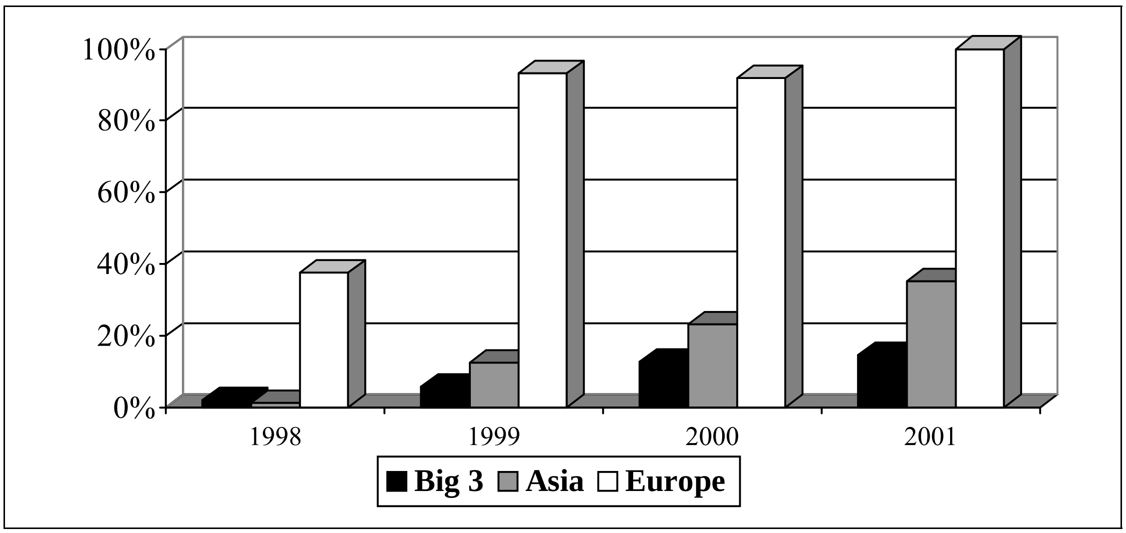


Source: Ward's Automotive Yearbook (Various Years)

3.7.3 Side Airbags

The installation of side airbags has risen steadily over the last few years. There is currently no regulation that calls for side airbags, but the side crash test requirements have become increasingly stringent. Much of the airbag industry's future growth rests with alternative airbag systems such as side and curtain (head) systems. Although there is no direct regulatory pressure to include side airbags, independent agencies that have an influence on vehicle content (e.g. NHTSA and IIHS) could initiate action if automakers fail to take initiative.[33] Safety attributes are among the most highly valued in a vehicle, which facilitates the whole process. There is a large divide between consumers that want safety features and those who are willing to pay for it, though. One industry official quoted the difference to be 85% who value safety features highly, but only 15% are willing to pay for it, which depending on the interpretation may validate the need for safety regulation. The average consumer cost of side airbag systems today is in the neighborhood of $330.[83] Figure 3-17 highlights the burgeoning side airbag market in the U.S.

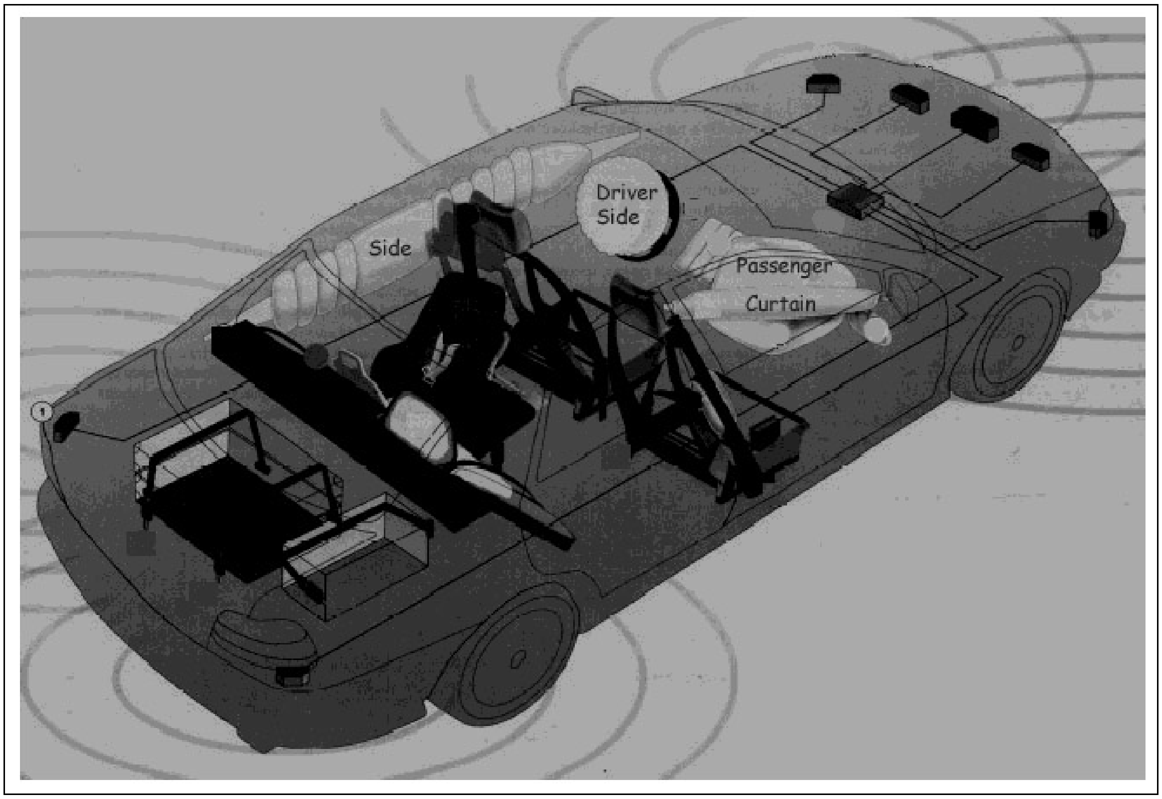
Figure 3-17 Side Airbag Installation Rates on Cars Sold in the U.S.



Source: Ward's Automotive Yearbook (Various Years)

The trend toward more safety content on vehicles has accelerated since the adoption of the passive restraint standard. The tendency has been for automakers to introduce safety features such as side and curtain airbags in luxury models first and then follow-up after a few years by including them on standard vehicles. For example, side airbag systems were typically included in Lexus, Acura, Infiniti, Audi, Cadillac, and Lincoln models one to three years before showing up in significant numbers on Toyota, Honda, Nissan, VW, GM, and Ford models. Figure 3-18 depicts the various airbag systems on a current production car.

Figure 3-18 Diagram of Modern Airbag Systems



Source: Adapted from a diagram as presented by Gerber Technology, http://www.gerbertechnology.com/. The black boxes near the front bumper of the vehicle are sensors, which are connected via wiring to the information hub, the control module. As discussed earlier the industry trend has been to move toward the use of one sensor to discern front impact crashes.

4 CONSUMER RESPONSE

The industry response to the eventual airbag regulation was well documented in the previous section, but how did consumers respond? Along with costs and product liability concerns, consumer acceptance of the safety devices had been cited as one of the major barriers to the adoption of an airbag standard. This concern may have also made the government more receptive to alternative strategies that addressed the problem areas in occupant crash protection.

4.1 IMPACT OF COMPLIANCE-RELATED VEHICLE ATTRIBUTE CHANGES AND ACCOMPANYING PRICE CHANGES ON NEW CAR SALES

The regulation requiring the inclusion of airbags on all vehicles appears to have had little impact on vehicle sales or sales mix. The dramatic sales shift away from passenger cars toward light trucks (particularly SUVs) was a phenomenon that coincidentally occurred during the same timeframe of the airbag requirement. Airbags were required in all light trucks only one year after a 100% requirement for passenger cars went into effect, suggesting the strong move toward SUVs had nothing to do with airbags. As Table 4-1 shows, there was also a significant sales mix change in favor of midsize cars at the expense of smaller cars. This may be partly attributable to a greater emphasis on vehicle safety, but other causes such as generally low fuel prices and consumer preferences for midsize cars play a large role.

Table 4-1 Percentage of Passenger Cars and Light Trucks Sold in the U.S. (1987-1997)

Model Year	*Passenger Cars*					*Light Trucks*							
	Sales (000)	Frac	Vehicle Size			Sales (000) Small	Frac	Vehicle Size			Vehicle Type		
			Small	Mid	Large			Small	Mid	Large	Van	SUV	Pickup
1987	10731	72.2%	63.5	24.3	12.2	4134	27.8%	19.9	59.6	20.6	26.9	21.1	51.9
1988	10736	70.2%	64.8	22.3	12.8	4559	29.8%	15	57.2	27.8	24.8	21.2	53.9
1989	10018	69.3%	58.3	28.2	13.5	4435	30.7%	13.9	58.9	27.2	28.8	20.9	50.3
1990	8810	69.8%	58.6	28.7	12.8	3805	30.2%	13.4	57.1	29.6	33.2	18.6	48.2
1991	8524	67.8%	61.5	26.2	12.3	4049	32.2%	11.4	67.2	21.4	25.5	27	47.4
1992	8108	66.6%	56.5	27.8	15.6	4064	33.4%	10.4	64	25.6	30	24.7	45.3
1993	8457	64.0%	57.2	29.5	13.3	4754	36.0%	8.8	65.3	25.9	30.3	27.6	42.1
1994	8414	60.2%	58.5	26.1	15.4	5572	39.8%	9.8	62.5	27.7	25	28.5	46.5
1995	9396	62.0%	57.3	28.6	14	5749	38.0%	8.6	63.5	27.9	28.9	31.6	39.5
1996	7890	60.0%	54.3	32	13.6	5254	40.0%	6.5	67.1	26.4	26.8	36	37.2
1997	8335	57.7%	55.1	30.6	14.3	6117	42.3%	10.1	52.5	37.3	20.7	40	39.3
1998	7972	55.2%	49.4	39.1	11.4	6477	44.8%	8.9	58.7	32.4	23	39.8	37.3

Source: Hellman and Heavenrich (2003) *Light-duty Automotive Technology and Fuel Economy Trends 1975 through 2003*, Report EPA.

By looking at how the sales of individual car models are affected when airbags are made standard, we can begin to understand consumer reaction to airbags. The change in sales between the years when an airbag is not available and when it becomes standard helps show how consumers responded to the airbag and its added cost. Table 4-2 shows that for the most part sales went up when airbags were added, even as the MSRP increased at an above average rate. When airbags were added, the average change in sales only goes down for luxury and sports cars and for Asian automakers.

When neither airbags nor ABS are made standard on a new car, which is the baseline case, average sales decrease in all categories except one: European automakers. The case of ABS falls somewhere between the baseline and airbag cases. Sales of European and Asian vehicles increased when ABS was added, while Big 3 average sales decreased. Compact, large and luxury cars dropped in average sales, while midsize and sports cars increased on average. Adding either airbags or ABS adds cost on average, which should depress sales, but the data on sales do not support this. The additional cost was not associated with lowered sales.

These findings are suggestive, not definitive. The sample sizes for the groups of individual car models used for this analysis are generally small, and other factors may be more instrumental. In any case, the addition of airbags on cars clearly was associated with increased sales.

Table 4-2 Annual Aggregate Sales and Price Changes (All, Region, Vehicle Class)

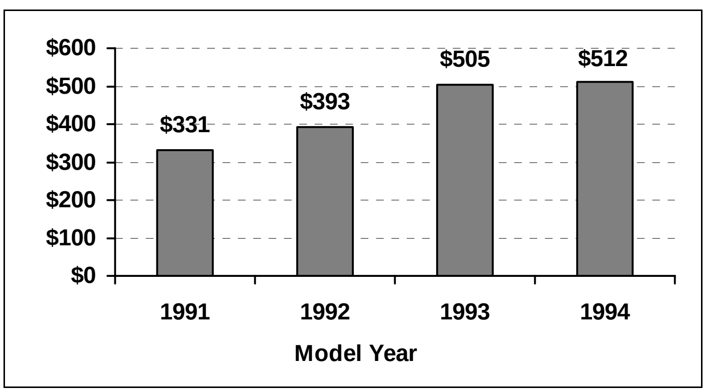
Break Variable Safety/Year/ Region/Vehicle Class		Number n	Δ Sales		Δ MSRP 2002$		Δ MSRP Current$	
			Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Safety Feature	1 Airbag	195	**1,042**	18,403	**$746**	$2,139	**$1,112**	$2,052
	2 Airbag	25	**831**	23,200	**$669**	$951	**$1,109**	$974
	ABS	50	**-1,377**	22,440	**$1,105**	$1,430	**$1,460**	$1,339
	Traction	44	**4,790**	13,962	**$341**	$1,993	**$630**	$2,265
Year	1989	103	**-6,287**	21,472	**$704**	$1,065	**$940**	$1,013
	1990	109	**-8,499**	24,116	**$378**	$2,331	**$613**	$2,084
	1991	117	**-9,078**	15,437	**$217**	$1,029	**$840**	$1,137
	1992	122	**-2,225**	16,224	**$797**	$2,594	**$1,237**	$2,617
	1993	121	**268**	14,990	**$426**	$1,963	**$900**	$1,829
	1994	115	**4,106**	21,912	**$605**	$1,416	**$1,340**	$1,523
	1995	105	**-2,916**	18,620	**$258**	$2,125	**$803**	$2,037
	1996	110	**-255**	18,640	**$363**	$945	**$806**	$1,097
	1997	113	**-1,520**	12,713	**$287**	$1,499	**$359**	$1,518
	1998	106	**-1,502**	20,402	**$466**	$1,661	**$314**	$1,570
	1999	100	**3,623**	17,513	**$519**	$999	**$339**	$956
	2000	101	**-1,523**	25,579	**$402**	$1,880	**$396**	$1,903
	2001	103	**-5,154**	13,323	**$643**	$1,707	**$517**	$1,719
	2002	97	**-865**	14,612	**$945**	$1,263	**$620**	$1,149
Big3	All	726	**-4,769**	23,534	**$446**	$1,063	**$665**	$1,050
	Airbag	99	**1,815**	25,784	**$652**	$1,545	**$1,033**	$1,453
	ABS	29	**-4,219**	27,425	**$1,401**	$1,371	**$1,743**	$1,287
Europe	All	268	**977**	7,968	**$558**	$3,241	**$902**	$3,153
	Airbag	46	**1,995**	8,100	**$841**	$3,361	**$1,265**	$3,067
	ABS	11	**4,023**	17,111	**$646**	$1,491	**$1,004**	$1,303
Asia	All	522	**-402**	14,979	**$541**	$1,181	**$730**	$1,305
	Airbag	74	**-640**	11,822	**$815**	$1,487	**$1,149**	$1,669
	ABS	15	**3,899**	17,423	**$1,167**	$1,383	**$1,427**	$1,299
Com-pact	All	509	**-3,748**	22,790	**$343**	$724	**$484**	$706
	Airbag	60	**410**	22,682	**$391**	$663	**$670**	$654
	ABS	13	**-2,219**	30,815	**$1,011**	$1,108	**$1,281**	$1,031
Mid-size	All	330	**-1,887**	23,958	**$397**	$856	**$603**	$862
	Airbag	47	**4,185**	25,325	**$675**	$756	**$995**	$473
	ABS	14	**3,149**	25,388	**$858**	$818	**$1,253**	$683
Large	All	102	**-3,690**	18,962	**$481**	$817	**$675**	$818
	Airbag	16	**6,360**	18,463	**$964**	$1,010	**$1,322**	$964
	ABS	6	**-4,879**	17,758	**$1,367**	$1,421	**$1,590**	$1,432
Luxury	All	457	**-482**	7,559	**$706**	$2,832	**$1,070**	$2,806
	Airbag	79	**-462**	8,559	**$884**	$3,208	**$1,350**	$3,043
	ABS	12	**-5,410**	10,824	**$1,385**	$2,402	**$1,911**	$2,210
Sports	All	125	**-2,443**	14,804	**$647**	$920	**$862**	$961
	Airbag	18	**-3,474**	19,480	**$1,212**	$1,216	**$1,654**	$1,332
	ABS	5	**2,016**	18,788	**$1,053**	$477	**$1,267**	$566
All	**Total**	**1,523**	**-2,254**	**18,924**	**$498**	**$1,696**	**$729**	**$1,693**

Table Notes: This table represents average annual sales and price changes. The safety feature refers to the average sales and price change when that equipment is made standard. Airbags include driver, passenger and side, and are treated equally (i.e. whether a driver airbag is made standard is treated the same as if a passenger airbag was made standard on a vehicle that already had a driver airbag, or on a vehicle that had dual airbags, but added side bags. The prices for the airbag systems are not perfectly equivalent, but as shown in the cost section of this report, they are close enough to be treated together in this table.

When analyzing consumer behavior in response to new or modified vehicle attributes and price changes brought about by regulation, there are a great many variables to consider. As mentioned earlier, the adoption of airbags transcended the typical regulation-forcing process, and became at least a partly market-driven phenomenon. Mannering and Winston went so far as to call the adoption of airbags a "rational market outcome," and ultimately the airbag was offered as much by automakers because consumers were willing to pay for it as the federal regulation (see Figure 4-1).[85] This point is certainly debatable, and others, including all of the industry people interviewed for this report, hold the viewpoint that first and foremost, the adoption of airbags was fueled by the regulation, and consumer demand was merely a secondary driver. This trend has continued globally where even countries in South America, for example, are considering some form of airbag regulation. Airbags, unlike emissions control equipment, offer a private as well as a public benefit.

Airbags, and more generally safety systems, have also become an array of attributes that signify status. Sophisticated safety systems first appear on expensive luxury vehicles, and after a period of time some of these technologies may show up on non-luxury models. Non-regulated safety systems such as ABS, traction control, side airbags, and advanced headlamp lighting systems offer not only added safety, but also added status. The regulation of airbags is unique in that it forced automakers to place a technology, which had been appearing primarily on the Mercedes and Porsches, into the most low-priced vehicles.

Figure 4-1 Average Willingness to Pay for a Driver-Side Airbag



Source: Mannering and Winston (1996).

4.2 INCENTIVES TO SPEED UP THE INTRODUCTION OF AIRBAGS

4.2.1 The Insurance Industry

The Insurance industry actively lobbied for airbags throughout the long regulatory deliberation. Insurance companies lobbied for passive restraint regulation to reduce their costs and at the same time improve their public image.[86] While the automakers and auto dealers may have done relatively little to promote airbags at first, the insurance industry played a prominent role. A Texas-based insurer, United Services Automobile Association (USAA), announced in 1988 that it would offer a $300 bonus to policyholders who purchased, or leased long-term, an airbag-equipped car.[87] The Association's chairman, Robert F. McDermott further stated: "USAA is also working with Ford and GM to develop an incentive program – recognition and prizes – for dealerships and individual salespeople who sell cars with optional air bags…for the first time in the industry, we're able to offer incentives to those who sell safety as well as to those who buy it."[88] The prizes included such things as two-week cruises and home video equipment. GM and Ford quickly committed to supporting the incentive program.

A discount in personal injury and medical payment coverage rates was the more typical incentive structure designed to encourage the purchase of the airbag option. USAA initially offered a 30% discount, but doubled it to 60% shortly thereafter. Other big automobile insurers such as State Farm and Nationwide offered discounts of 30-40% to stimulate airbag sales. Allstate Insurance Co. had even offered a 30% discount on medical and no-fault personal injury insurance in 1973 in an attempt to induce consumers to purchase GM's new airbag option.[86] The incentives at that time had little impact on consumer choice.

The impact of insurance incentives between roughly 1988 and 1997 is not well understood. Consumers accepted the regulated technology of airbags and this acceptance was assisted to a certain degree by savings in auto insurance payments to help offset the added cost of the technology. The support of airbags by the insurance industry also gave validity to the safety device, which led to higher consumer confidence and a smoother transition to an airbag-equipped vehicle fleet.

Figure 4-2 Allstate Airbag Advertisement (1975)

Figure 4-3 Allstate Airbag Advertisement (1990)

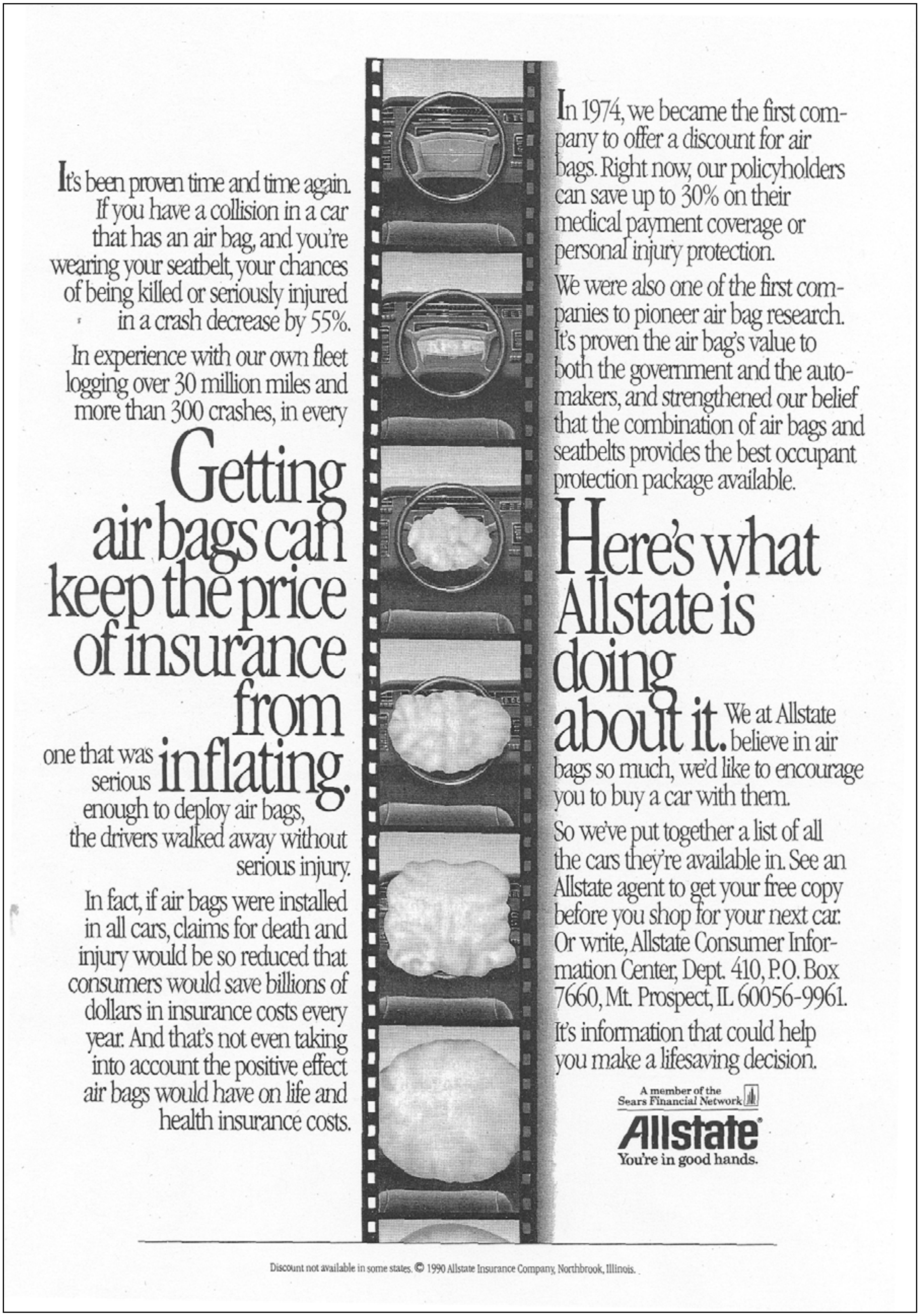
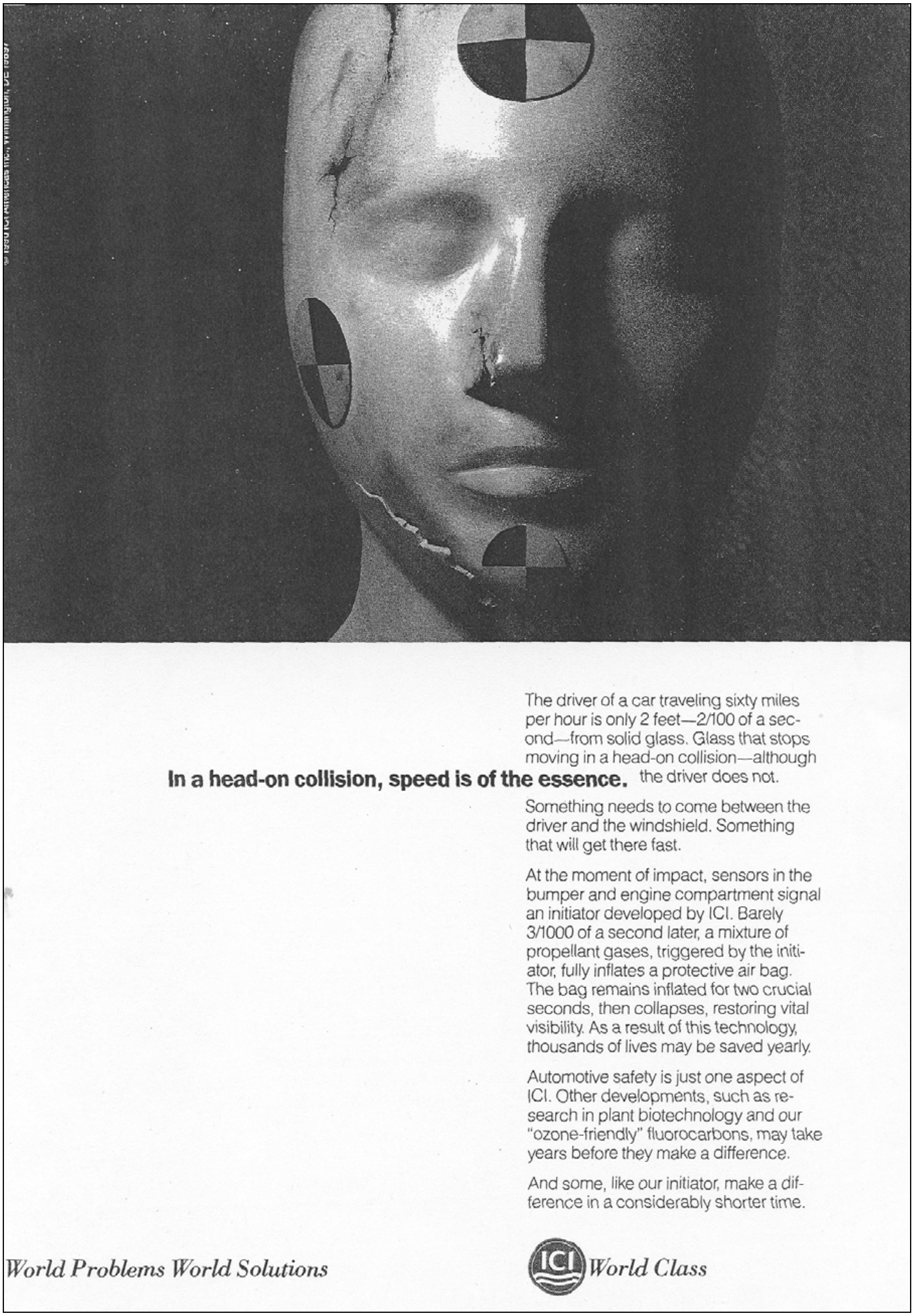


Figure 4-4 Automotive Supplier Airbag Advertisement (1991)



4.2.2 Automakers & Auto Dealers

Automakers have a plethora of marketing techniques to overcome consumer resistance to a new vehicle, reduce excess inventory, and maintain market share. For example, in 1995 when Ford offered the remodeled Taurus, the flagship vehicle for the company, a large rise in price accompanied the styling changes. Consumers rejected the higher price, which forced Ford to discount the new model with rebates and lease deals. Despite a sticker price of $19,150 for the base model, the average transaction price quickly fell to roughly $18,000.[89]

Incentives and rebates, spearheaded by domestic automakers, have become the most visible form of consumer incentives in recent years. This trend developed during the late 1970s through the 1980s when expenditures for promotional programs grew much faster than expenditures for advertising.[90] While advertising is effective in producing long-term brand loyalty, promotions are primarily limited to increasing short-term sales. Such promotional strategies have been the subject of great debate due to possible negative effects. These adverse effects include 'forward buying,' which has been characterized as stealing sales from the future by encouraging a car shopper to purchase more quickly in order to receive the deal. The resale value of used cars that have had significant monetary incentives have been shown to fall faster than cars with no such incentive. An analysis by Edmunds.com found that about 85 percent of the value of all new-car incentives washes through to the used car prices of the same vehicle (i.e. $3,000 incentive = $2,550 instant depreciation on used car).[91] Larger and more widespread incentives may also lead to a consumer perception of product inferiority.

It was reported in October 2002 that GM incentive spending was $3,855 per vehicle in the third quarter of that year, which is not an unusually high figure.[92] A Vice President of GM, Bill Lovejoy, responded by saying, "incentives will stay in place until demand is more aligned to capacity." The capacity utilization trend has been steadily pointing downward for domestic automakers, which would seem to imply that rebates will remain an integral part of the car selling business for some time to come. GM also raised rebates on midsize vehicles in 2002 due to a lag in sales.[93] Carmakers offer incentives to stimulate sales, but the firms often couple rebates on less popular models with price increases on high-selling vehicles.[94] Incentives help move specific models that do not sell up to expectations for a variety of reasons, one of which may be added cost due to regulation. The bundling of options for cut rates or the offering of free options is another common form of incentive. As mentioned in the cost section of this report, Ford and GM bundled driver airbags with other options such as air-conditioning and anti-lock brakes for an effective price much lower than what the airbag option cost alone.